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ELSWICK EXHIBITS OF WAR MATERIALS AT THE NEWCASTLE EXHIBITION.

THE Elswick war *materiel* may be classed generally under the following heads: (1) War vessels complete; (2) ordnance proper sold as separate stores; (3) mountings, carriages, etc.; (4) torpedoes and appliances. This division may not be that recognized at Elswick, but it best meets our present purpose. Under the heading of war vessels complete would come the Victoria—formerly called the Renown—with her 110½ ton guns, 10 in. gun, and 6 in. guns, down to the quick fire and machine guns. The Dogali, for Italy, the Panther and Leopard for Austria, and the Chihyuan and Chingyuan for China, as well as the Rattler and Wasp for England, are recent ships coming under the heading of vessels complete. Ordnance proper would comprise the 110½ ton breech loading guns supplied for the Benbow, and all the heavy guns sold separately, noticed hereafter, as well as the quick firing and machine guns, down to the Gatling mitrailleuse. Mountings may accompany guns, as in the case of the Benbow, or may be made separately, as in the instance of two Krupp guns which are being mounted for a foreign ship, together with guns made at Elswick, or in the case of the cosmopolitan forts constructed for the defense of Spezia harbor, which are to have Gruson armor, Krupp 119 ton guns, Elswick mounting and machinery, and probably Italian projectiles. Torpedo work is quite a distinct department, which is chiefly carried out at Bear-lane Works, Southwark—formerly Vavasseur's. This we do not propose to notice at this time, and the vessels complete we must leave to stand over for the present. The vessels are represented by models at the Newcastle Exhibition. These we hope to deal with by and by, but the first claim on us is that of the guns themselves.

The annexed table particularizes the guns made at Elswick and exhibited. The 110½ ton gun is represented by a model. The smaller guns are actually exhibited. The table gives the most important data connected with the guns except the muzzle energy, which is easily calculated. That of the 110½ ton gun comes to 57,580 foot tons. We recorded the highest velocity in the arsenal at the time of trial as 2,149 ft., which makes the energy 57,630 foot tons. The perforations on the table herewith are considerably lower than we should make them. Foreign perforations are low. Those given in the Austrian and other naval almanacs would nearly agree with these given at Elswick. Those in the naval gunnery official book agree very closely with ours, and we have never seen reason to change our system of calculation, seeing that the results obtained in perforation with the best projectiles are generally rather more than any of us calculate.

Before dealing with the guns before us individually, it may be well to call attention to their general characteristics. The leading feature is of course the change from the short guns suited to the quick burning powder of twenty-five years ago to the long pieces by means of which slow burning powder is made to produce enormously greater results, while the gun is subjected to a much lower maximum pressure. This is a question of proportion in conjunction with length. In the new type guns the pressure is kept up to the muzzle to such an extent as to call for greater strength in the chase of the piece. Captain Andrew Noble, who took the lead in working out this question, has illustrated the progress in gun construction in Fig. 8, which is taken from a paper of his. The diagrams represent the work which is got out of 24 tons embodied in an old type gun and 26 tons in a wire Elswick gun. It will be seen that in the old piece, which is a 12 in. muzzle-loading gun, a velocity of 1,180 ft. is imparted to a projectile which weighed 615 lb. at the cost of a maximum pressure of 31 tons per square inch. In the new gun, with caliber of 10 in., a velocity of 2,225 ft. is given to a projectile weighing 450 lb. with a maximum pressure of only 17 tons per square inch. In the old gun, short as it is, the pressure has decreased to 1·6 tons at the muzzle, so that in it clearly additional length would have been a mistake, whereas in the new gun there is at the end of a long bore still 5·2 tons pressure, so that there would positively be more in favor of lengthening this gun than the other. The total stored-up work or muzzle energy in the old gun is 5,939 foot-tons, and in the new 15,450 foot-tons. Hence, out of 26 tons is got more than 2½ times the work on the new system of slow powder and long bore that was obtained from 24 tons on the old system of quick burning powder and short bore. In justice to the old guns, however, we must add that the pattern existing in the service is decidedly better than that shown in this figure. The initial velocity of the projectile of the 25 ton muzzle-loading gun is given in the new official book drawn up in the gun factory as 1,292 feet, giving a muzzle energy of 7,120 foot-tons, which is a decided improvement of 5,939 foot-tons, but affects the comparison with 15,450 foot-tons only in degree; the latter remains more than twice as great as the energy of the old gun's projectile. On Krupp's method of comparison, *i. e.*, the energy per ton of gun, the new wire gun has 643·9 foot-tons, and the old gun 237·0 or 284·7 foot-tons per ton of gun.

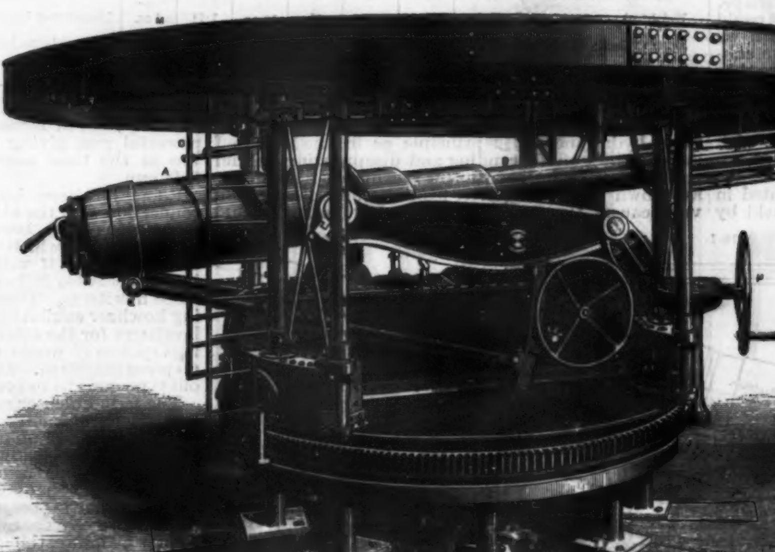


FIG. 3.

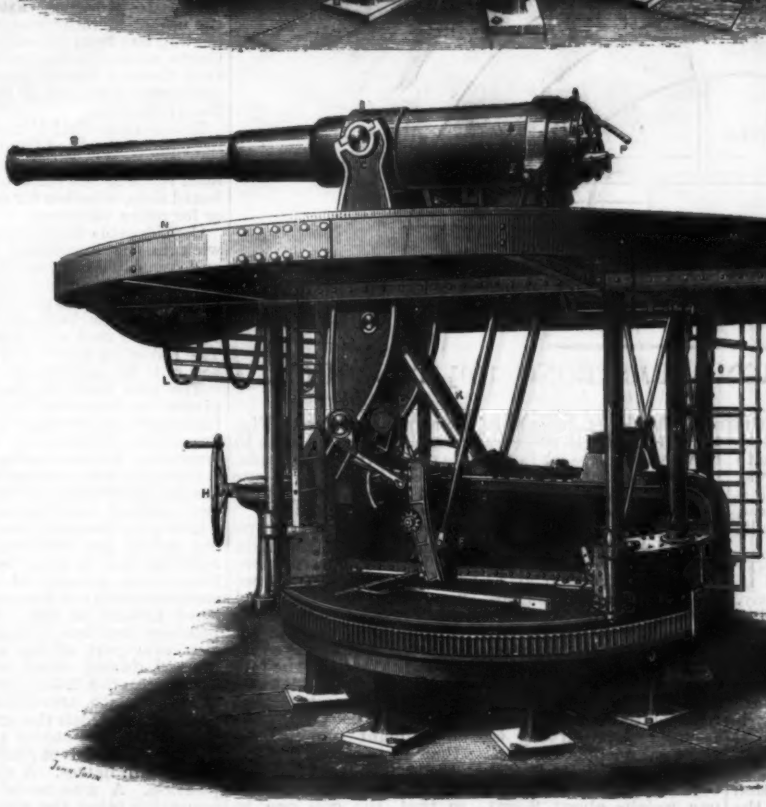


FIG. 4.

NEWCASTLE EXHIBITION—SIX-INCH B.L. GUN ON DISAPPEARING CARRIAGE.

The proportions of the gun form the principal feature of new type guns, but immediately connected with this question is that of proportion and weight of projectiles. This deserves notice the more because Armstrong and Krupp obtain their energies in different ways. The energy being made up of the weight of projectile multiplied by the square of the velocity, may depend on weight and velocity in varying proportions. Thus, in the Elswick 110½ ton gun the projectile is much lighter and the velocity higher than in Krupp's 119 ton gun. The weight, diameter, and expression $\frac{W}{D^2}$ which expresses the power to keep up velocity, is in each gun respectively 1,800 lb., 16·25, and 0·42, and 2,028, 15·75, and 0·82, the velocities being 2,149 and 1,900. The Elswick projectile has a great advantage at short ranges—that of Krupp at long ones. The long heavy projectile has more power to overcome resistance, and also owing to the velocity being less the resistance is less. The Elswick gun shows the best ballistic result; but if it be asked how it comes that Krupp perseveres in his system, the answer is that probably both Krupp and Armstrong are right, for their guns are meant for different purposes. The 110½ ton gun is for the navy; the number of rounds carried is necessarily limited on board ship—in fact, lamentably small—and thus decrease in weight is a great object. Krupp's gun has hitherto been used for coast defense, when long range may be an advantage and weight a secondary question. In short, for Britain the light projectile and higher velocity is the best combination; while the greater weight and lower velocity may be best for Continental coast armaments.

It will be noticed as we proceed that the application of hydraulic power to operations connected with guns and carriages is a special characteristic of Elswick. There are other features which belong to individual guns or to a single class. One of these which we notice here, because not exhibited in any specimen in the exhibition, is the employment of steel ribbon in gun construction. This, by its great powers, enables a gun to be made of greatly increased strength in proportion to its weight. The advantages claimed for the ribbon construction are (1) that steel in small section may be obtained with greater strength than is possible in any other form; (2) that each layer may be brought to its correct tension; (3) that the danger due to the existence of flaws is reduced to a minimum. Ribbon is wound on circumferentially, and laid longitudinally, as in 1881, and the winding is performed by means of Sir W. Armstrong's machine for giving the tension required for each layer. Italy has obtained some of these pieces from Elswick. Guns are now made entirely of steel. The individual features of each piece may be best dealt with in its own description.

The first exhibit to notice is the 110½ ton breech loading gun—A on table—which is the most powerful

gun in the world. At the Royal Arsenal the muzzle energy obtained with 850 lb. of German powder, and a pressure of 19·9 tons, was 57,630 foot tons, the velocity being as above mentioned, 2,149 ft. A still larger amount has been estimated for this gun, and there appears to be every reason to say that more might be got, seeing that the pressure is not high, and might be much increased without injuring the gun. Krupp's 119 ton gun on one occasion gave an energy 50,780. This is the highest Krupp record we have seen. It is 6,850 foot tons less than the Elswick gun. We could better compare the results if we knew the pressure in Krupp's gun. Probably, however, the pressure is kept well down. The natural tendency to rivalry in gunmakers is modified by the reflection that a mishap would be very damaging. The pressures adhered to are so reasonable that surprise may be felt that the guns are not [illegible]ed rather more. The old type guns were habitually subjected to higher pressures. We are inclined to think, however, that it is wise to keep well on the safe side at present.

We now employ a very large charge, which is made to act in a manner which is admirably suited to the circumstances of the case. The powder burns slowly, and keeps up the pressure as we have noticed above. We are dealing with an enormous force, which is acting as if subject to scientific control. We cannot help wondering whether circumstances might not arise which might cause the powder to behave differently, and then we might have to reckon with a very different rate of increase from what could take place in old days. Quick burning powder was force in a bad shape, but its very bad action gave the guarantee that it could hardly surprise us by behaving worse. It is as if we had dealt with a violent dwarf for which we have substituted a docile giant. Can we be perfectly sure that the giant may not some day behave badly? We hope he will not. It appears, indeed, to be very difficult to make cocoa powder burn rapidly, but we should be glad if our government would make experiments with it in various conditions, such as after being broken, exposed to dry heat, and the like.

Figs. 1 and 2 show the 110½ ton gun as mounted in the turret of the Victoria. The gun is shown held by bands, B B B, to the bed, *c c*, which moves along the slide beneath, which is pivoted or hinged in front at E. The recoil thus acts along a plane parallel and close to the axis of the piece, whatever may be the elevation at which it is fired. Consequently, the force of recoil is nearly constant with the same charge. H is the turret, G the port, and D the loading gear. The hydraulic lift is shown below the middle of the slide.

The chief difference between this piece and the large breech loading guns which immediately preceded it, such as the 115 ton and 100 ton guns supplied to Italy, is that the steel tube extends unbroken from end to end instead of being made in two lengths. Of course there are minor differences in detail and the length is increased, being 43 ft. 8 in. in all. The turret is rotated and the gun itself run in and out by a hydraulic gear. The operations of loading and working this gun are performed by the same means. The breech block is unscrewed from its seat in the gun, withdrawn, carried to one side to make room for the operation of loading. This is performed by hydraulic lift and rammer, by which the projectile and charge are in succession brought up and entered in the bore, after which the breech block is replaced and screwed home. The obturator is one proposed by Vavasseur, in which copper takes the place of the asbestos employed in the De Bange obturator.

The 10 in. breech loading gun, B in table, is to be mounted in the stern of the Victoria; the figures in the table show its powers. It is of the same general type as the 110½ ton gun, as are the 9·27 in. and 8 in. gun—C and D in table. For land service these guns are made with trunnions. For sea service it is convenient to employ bands holding them down, as in the case of the 110½ ton gun.

Figs. 3 and 4 show the 6 in. breech loading gun—F in table—mounted on a hydro-pneumatic disappearing carriage. The gun, A B, rests on the extremities of levers, C D under the trunnions, and E F, under the breech pivoting at C and E, on the gun, and D and F on the lower carriage. At K is a recoil press, which has two chambers. The recoil of the gun is absorbed by driving fluid from the recoil chambers through a valve into an air chamber, compressing the air on the same hydro-pneumatic principle as in the Moncrieff system, the gun descending and disappearing behind the parapet or wall of the pit in which it is mounted, as shown in Fig. 3. After loading, the opening of a valve causes the compressed air to drive back the fluid and raise the gun into the firing position, as shown in Fig. 4. This system of protection, which has been shown to be very complete, as in the case of the Hercules trials, has been adopted for coast defense, especially in our Australian colonies. This system of mounting is now being applied to guns of 70 tons weight at Elswick.

The 6·3 in. and 16 pounder muzzle loading old type guns and the much older 40 pounder breech loading gun—G, N, and H in table—serve to illustrate the progress in gun construction at Elswick. The 40 pounder we regard as perhaps the most successful of all the original Armstrong guns. It was well proportioned, of sufficient size to give the advantages of breech loading, and yet manageable. It has been superseded, but it played its part well in its day—so well that in the midst of the late reaction in favor of the muzzle loading system might be found a reserve clause in favor of the 40 pounder. The 4 in. jointed breech loading 25 pounder has an interest peculiar to itself. It is the elephant gun for carriage on elephants' backs; that is to say, it is made in three pieces, A, B, and C, Fig. 7, which are screwed together and can be readily taken apart. Each one weighs about 8 cwt., so that the gun can be carried on the backs of three elephants. By this means a very powerful weapon, discharging a projectile with a velocity of 1,920 ft. per second, can be carried over country which is impassable for wheeled carriages. This design has existed for a few years now, and has been wholly worked out at Elswick, being unique. For some time we abstained from referring to it in our columns, because we thought it was unpatriotic to suggest the idea to Russia, the power that with ourselves would be most likely to be interested in the question. Russia now, however, has carried the principle of taking guns asunder still further, and, moreover, it seems very unlikely that she or any other power could avail herself of this particular design, seeing that no power but England possesses trained elephants, and these animals cannot be turned out by a factory. The Elswick mountain 7 pounder gun does not appear to be exhibited. It took asunder in two pieces. Each one, weighing 200 lb., was carried on a mule's back. It furnished, instead of the popgun formerly used in mountain batteries, a comparatively powerful gun, giving 1,500 ft. muzzle velocity, which was at the time more powerful than our 9 pounder field gun.

Rifled howitzers have latterly come into notice in connection with the attack of ships' decks. Our coaling stations have been at a small cost supplied with these weapons, which would threaten the existence of armorclad ships if well managed. For some purposes in the field also it has been found desirable to have rifled howitzers. There is a 3·3 in. field muzzle loading howitzer exhibited by Elswick—M on table. For howitzers for the attack of ships, some of the mountings spoken of would be very applicable, but there is no piece exhibited. In the British service some of our old type guns have been made to do duty as howitzers.

The term quick or rapid fire gun was devised to describe a gun of small caliber, the projectile and powder for which are combined together in a metallic cartridge case, the loading, consequently, being rapidly effected, and the rate of fire considerably increased. The original 6 pounder rapid fire gun was intended for use either on board ship or from a boat, and the conditions were that it should be able to fire twelve rounds a minute, the gun being destined chiefly for use against torpedo boat attack. Of late an extension of the use of metallic cartridge cases and simultaneous loading has been carried out by Sir W. Armstrong & Co. to guns of considerable shell power and penetration, thereby largely increasing the area which can be effectively defended by guns of the limited capacity of the 6 pounder.

It is obvious that if a considerably increased rate of fire can be obtained from a weapon firing a 30 lb., 40 lb., or even heavier projectile, a great addition has been made to the value of the smaller caliber guns on board ship, whether for defense against torpedo attack or for other purposes.

Considerable improvements had been effected at Elswick in the mountings of the smaller rapid fire gun, and suggested the possibility of extending the principle to heavier guns. The Elswick automatic recoil mounting for the 3 pounder Hotchkiss rapid fire gun, R on table, has been, in fact, the germ from which a 30 pounder and a 70 pounder mounting have arisen. The following account of this mounting will enable its action to be understood.

The gun itself is placed on a rocking slide, which pivots on trunnion bearings, the gun only moving backward and forward on the slide. The elevation or depression is given by rotating the slide round its trunnions, by means of a shoulder piece attached to it. A clamping arc is fitted to the right side, so as to fix the gun at an angle of elevation required. In front of the trunnion bearings are screwed two piston rods, which pass through glands into the recoil presses, forming part of the revolving bracket. The bore of the recoil presses, F, from being made slightly conical, allows a free passage of water past the piston at the commencement of the recoil, which is gradually diminished toward its end. At the rear of the trunnion bearings are two springs contained in boxes, which also form part of the rocking slide, and, being compressed during recoil, serve to return the gun immediately to the firing position. The rocking slide is provided with trunnions, which fit into a revolving bracket, on which the gun is trained horizontally by means of the shoulder piece. This revolving bracket is carried on a pivot plate, to which it is attached by a clip ring in halves. A clamp fixes the bracket in any position. A gun metal pivot at the center of the mounting takes the weight of the mounting, and reduces the friction when training. This bracket carries a thin steel shield for protection against rifle fire. Since the gun always recoils in the line of fire, the strains of recoil never vary. From the pressures indicated in the recoil presses during the experiment, the maximum strain was found to be 6·7 tons, and the mean strain 4·75 tons, the total amount of recoil being 4 in. Assuming the powder pressure to be 15 tons per square inch, a strain of 40 tons per square inch would be given off on the stand at the center of the gun in the case of the non-recoil mounting, so that it is seen how much the mounting is relieved by the adoption of a certain, though small, recoil. As the gun is allowed to recoil, a guard is fitted over the trigger in the pistol to prevent the use of the trigger for firing. A lanyard is attached to it and led through the brass guard in rear, so that the man at the shoulder piece can fire by pulling the lanyard. A knot is made in the lanyard, so that the gun cannot be fired if it does not return into the firing position. A rate of fire of about twer*y

Weights, &c., of Guns and Shell, &c.

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.
	16·25in. B.L.	10in. B.L.	9·27in. M.L.	8in. B.L. Howitzer.	6in. B.L. Howitzer.	6in. B.L.	6·3in. M.L., old type, built for Australian Government.	40-pounder B.L., old type.	30-pounder B.L., rapid fire.	32-pounder M.L., old type.	12cm. Howitzer.	4in. jointed B.L.	3·3in. M.L. Howitzer.
Length of gun in inches	524	320	192	86	65	268·8	120·75	120	170·5	108	67	110·3	70·5
Weight of gun in tons	110½	26	14	3	21 cwt.	5	61 cwt.	35 cwt.	34 cwt.	50 cwt.	9 cwt.	25 cwt.	3·7 cwt.
Weight of shot in lbs.	1800	450	300	180	80	100	80	40	30	32	32	25	18
Weight of powder in lbs.	960	250	53	15 max.	8 max.	50	12	7	9	8	3 max.	12	2 max.
Muzzle velocity in feet per second	2148	2225	1470	—	—	1940	1362	1380	1900	1600	—	1920	—
Penetration in inches	33·7	23·7	12·9	—	—	12·2	7	5·5	6·9	—	—	6·9	—

	N.	O.	P.	Q.	R.	S.	Gatling guns.
	16-pounder M.L.	12-pounder B.L.	7-pounder B.L.	5-pounder B.L.	3-pounder Hotchkiss.	2-pounder B.L.	
Length of gun in inches	73	32·2	69·4	70·86	80	48	Diameter of bore, 0·45in. } 6 barrels.
Weight of gun in cwt.	12	6	4	5	506 lb.	168 lb.	63 rounds can be fired in 2½ seconds } 6 barrels.
Weight of shot in lbs.	16·1	12	7	5	3·28	2	Muzzle velocity, 1315ft. per second } 6 barrels.
Weight of powder in lbs.	3	4	1½	10 oz.	1·71	4 oz.	Diameter of bore, 0·45in. } 10 barrels.
Muzzle velocity in feet per second	1555	1700	1440	1250	2062	1080	104 rounds can be fired in 2½ seconds } 10 barrels.
Penetration in inches	—	—	—	—	4½	—	Muzzle velocity, 1315ft. per second } 10 barrels.

FIG. 1.

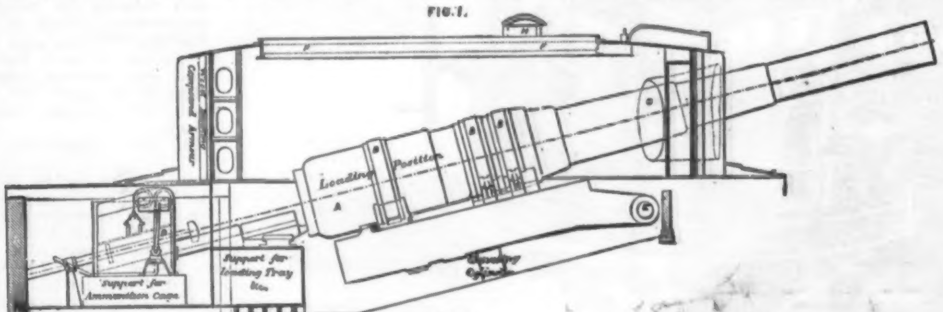
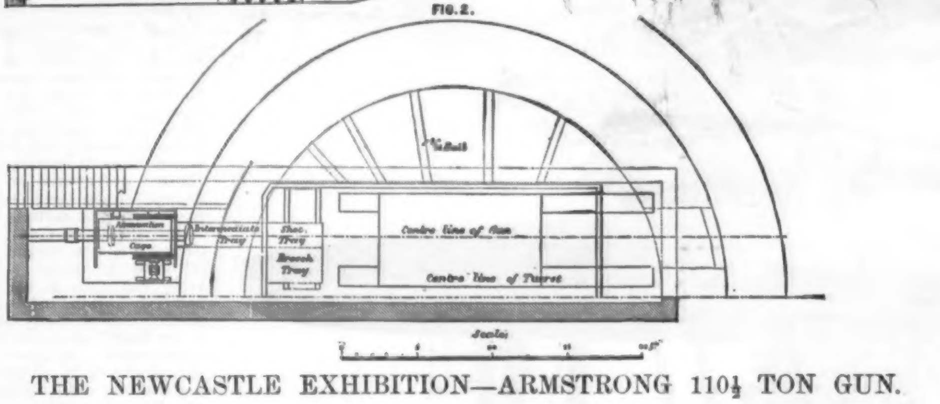
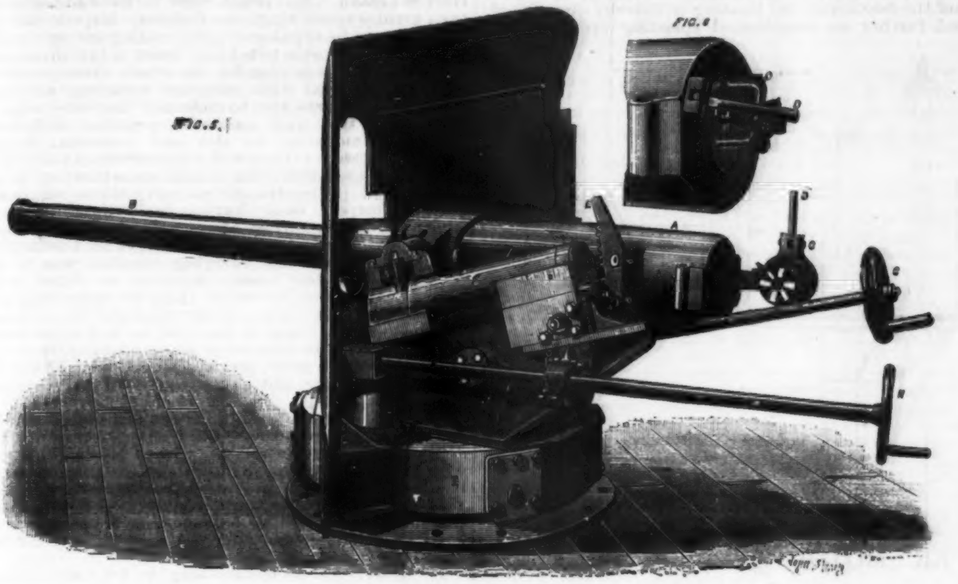


FIG. 2.



THE NEWCASTLE EXHIBITION—ARMSTRONG 110½ TON GUN.

rounds a minute has been obtained with this gun. The 30 pounder rapid fire breech loading gun, caliber 4·724 in., or 12 cm.—I on table—fires a shell of 30 lb. with 9 pounds of powder. It is shown in Fig. 5. The gun is entirely of steel, its total length 14 ft 2½ in., length of bore 35 calibers, and weight 34 cwt. This



THIRTY-POUNDER RAPID FIRING GUN.

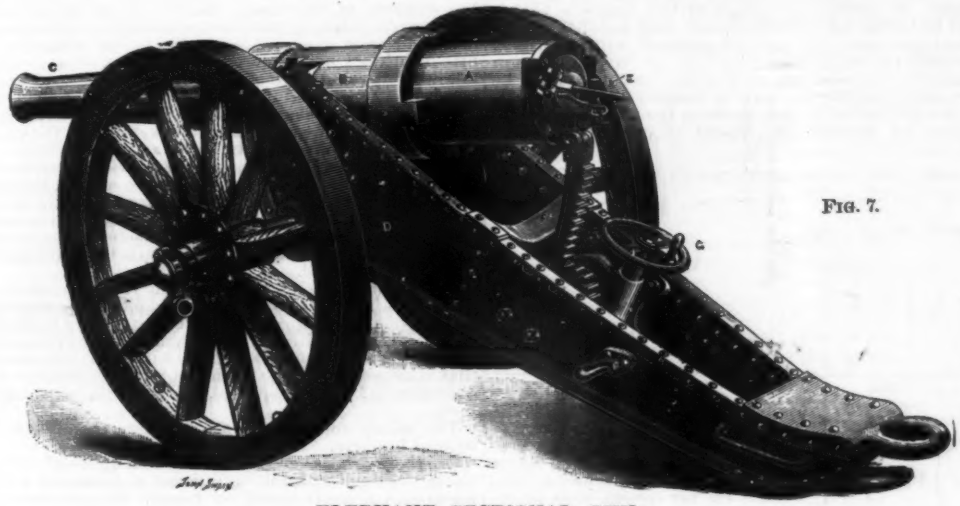
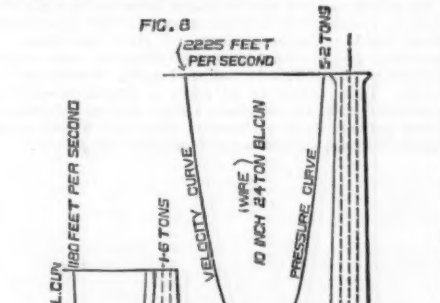


FIG. 7.

ELEPHANT SECTIONAL GUN.

NEWCASTLE EXHIBITION—NEW TYPE GUNS.

gun does not exhibit the feature on which we have specially dwelt, namely, the rocking slide, which is, however, embodied in a later pattern, but it has other good points. The breech is closed on the interrupted screw system, the breech block being formed on two steps, both of which have portions of an interrupted screw on their surfaces, the threads on one step standing opposite to the blank spaces on the other. This distributes better the strain on the block, and makes the opening and closing more rapid.



The breech block swings into place, and is secured by a small turning movement. This may be well seen in Fig. 6, which shows the breech open. The gun is fired by electricity, the mechanism for that purpose being simple and ingenious. In the base of the cartridge case is screwed an electric primer, against which a brass pin carried in the axis of the breech block presses. This pin is in communication with the electric wires, which carry the current to fire the primer, only when the breech block is closed, and secured by turning the lever downward against the rear of the block. In this manner all danger of accidental discharge is avoided, and complete security gained. The mounting consists of an under carriage or slide, I in Fig. 5, carried on four rollers, and working round a central pivot. To the front is attached a shield to protect the gunners. The training is effected by moving a wheel and shaft, H K, acting on a pinion on the left of the carriage, working in a rack on the bed plate, and the elevating by a similar wheel, G, working a rack, pinion, and worm, also on the left of the carriage. The shafts which actuate the training and elevating gear are both brought well to the rear, and close to the wooden shoulder piece against which the firer presses, so that he has everything close to his hand. The carriage proper works on top of the slide, the recoil being checked by means of a hydraulic Vavasseur buffer, F. The running out is automatic after each round. This gun has been most successfully tried at the government ranges, a rate of fire of eight to ten rounds per minute being obtainable.

Fig. 9 shows the newest pattern quick firing gun, in which the "rocking slide" noticed above is embodied. Here the gun, A, and recoil, C, cylinder move together. The breech open is seen at B. The shoulder piece, D, enables the piece to be fired like a small arm, the recoil being absorbed independently. The eight rounds of ammunition at E, and eight rounds on the other side of the piece, travel with it. F is the steel shield.

Designs for a 70 pounder rapid fire gun have been completed, in which in the main the arrangements adopted for the improved 30 pounder with the rocking slide have been followed. Should this gun give good results, it is thought possible that rapid fire guns may replace on board ship all the lighter artillery, whether forming the main armament of small vessels or the auxiliary armaments of large ironclads. There is a 3 pounder quick firing gun on a non-recoil carriage, in which the gun has no movement or recoil. The carriage and mounting, probably in virtue of its elasticity, absorbs much of the shock, and enables the gun to bear the strain, which is, however, so much more satisfactorily dealt with in the recoil mounting. Hotchkiss guns have been manufactured at Elswick in large numbers, especially for the British government. They are used extensively on board ships and in torpedo boats.

Sir W. Armstrong & Co. are the English makers of the Gatling gun, which may be described as a machine rifle. It possesses a positive automatic feeding arrangement, and the whole mechanism of the gun is simple and trustworthy. The gun is ten-barreled, the barrels being grouped round a central spindle. To the breech end is affixed the feed drum, containing 104 cartridges; and on turning the handle these are successively forced into the cylinder of the gun, which contains the mechanism for pushing them into the barrels, firing them, and withdrawing the empty cases.

The gun can fire from 800 to 1,000 rounds a minute, at any angle of elevation or depression. The total weight of gun and stand is 1½ cwt. The gun is either placed on a stand on the bulwark of a ship or boat or is adapted to service in the field by means of a traveling carriage and limber. A special form of field carriage has also being designed, which enables the gun to be fired while on the move, an important advantage in many instances. It is specially claimed for this machine gun that its feed does not depend upon gravity.

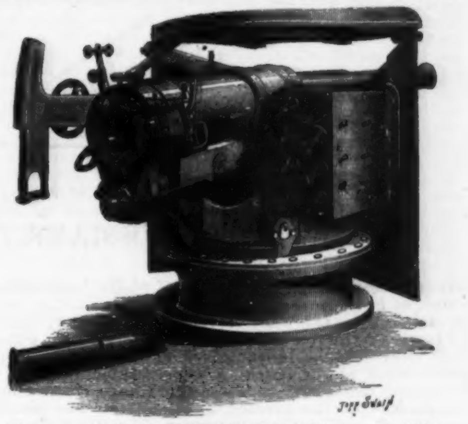


FIG. 9.—NEW THIRTY-POUNDER QUICK FIRING GUN.

consequently the gun can be fired in any position without affecting the feed—vertically if desired. This is important in a mitrailleuse proper, which it may be desirable to thrust into any corner and bring to bear downward and upward at the extreme angles in ditches of forts, and at boats in sea service.—*The Engineer.*

EXHIBITION OF FLAX CLEANING MACHINERY IN CHILI.

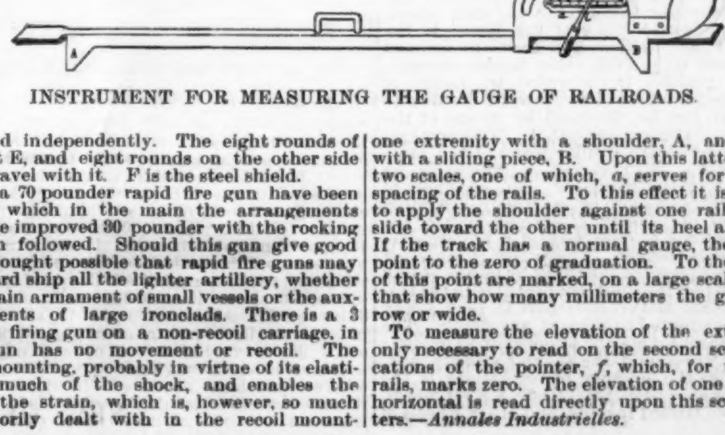
ON November 1 of the present year an exhibition of the above named class of machinery is to commence at Santiago, Chili. In the colonial period flax ranked high in importance among the productions of the country. Recently, however, the cultivation of this product has tended to decline, wheat farming and mining attracting more attention. The government is now desirous of reawakening interest in the flax industry, and hence offers a premium for flax machinery. The exhibition is held under the auspices of the Society for Industrial Improvement. This organization was established by the government four years ago. The design is to have a competitive exhibition of machinery for separating the fibers, stems, and leaves of the flax plant, so as to bring the flax into condition to be spun. The site is the experimental gardens of agriculture, and a prize of $1,000 for the best machine has just been announced by decree. Owing to her abundant water supply, Chili seems peculiarly well adapted for this industry. There is no reason to doubt that in the near future a good market for such machinery may exist within her borders. The best European machines will, it may be presumed, be sent to the exhibition. We hope that American manufacturers by their enterprise and interest may successfully compete, and enable this country to carry off the prize.

RULE FOR MEASURING THE GAUGE OF RAILROADS.

FOR the purpose of rendering more accurate and practical the indications obtained on railroads by means of the rule and level for measuring the gauge, and the elevation of the external rail on curves, Mr. John, engineer of the state railroads of Austria, has devised a simple and precise apparatus, which we figure herewith.

It consists essentially of a metallic rule provided at one extremity with a shoulder, A, and at the other with a sliding piece, B. Upon this latter are engraved two scales, one of which, *a*, serves for measuring the spacing of the rails. To this effect it is only necessary to apply the shoulder against one rail, and move the slide toward the other until its heel abuts against it. If the track has a normal gauge, the needle, *l*, will point to the zero of graduation. To the left and right of this point are marked, on a large scale, the divisions that show how many millimeters the gauge is too narrow or wide.

To measure the elevation of the external rail, it is only necessary to read on the second scale, *b*, the indications of the pointer, *f*, which, for two horizontal rails, marks zero. The elevation of one rail above the horizontal is read directly upon this scale in millimeters.—*Annales Industrielles.*

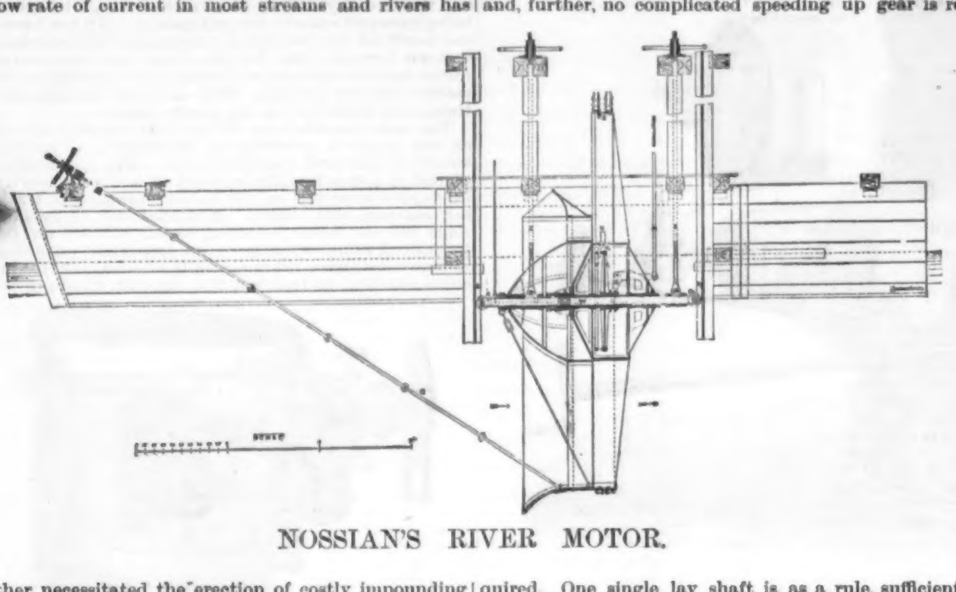


INSTRUMENT FOR MEASURING THE GAUGE OF RAILROADS.

NOSSIAN'S RIVER MOTOR.

By JULIUS MAIER, Ph.D.

THE utilization of the waste power of large streams and rivers, by the installation of water wheels, has occupied the attention of the hydraulic engineer we may say for centuries past, but has not advanced as much as other branches of mechanical engineering. The slow rate of current in most streams and rivers has this class, reach a maximum effect when the speed of the working wheel is $0{\cdot}5\sqrt{2gh}$ (the same law also applies to all undershot paddle wheels and floating mill wheels). But in Nossian's river motor maximum effect is obtained at a speed of $0{\cdot}7\sqrt{2gh}$, or even $0{\cdot}9\sqrt{2gh}$. Owing to the higher speed and large number of revolutions, the driving belt need not be tightly stretched, and the friction of the bearing is thereby diminished, and, further, no complicated speeding up gear is re-



NOSSIAN'S RIVER MOTOR.

either necessitated the erection of costly impounding dams, as in the case of stationary turbines, or, in order to make up for the want of velocity of current, tended to increase the size of the wheels to such an extent that they become too cumbersome and costly. Nossian's river motor marks a considerable progress in hydraulic engineering. In an ordinary river wheel, the surface of the current alone acts on the paddle, and the effect of the larger masses of water below the surface is completely lost, while Nossian's motor pre-quired. One single lay shaft is, as a rule, sufficient, and from this a direct transmission to the work can be made. A further advantage of this motor is that it can be moved up or down stream, and installed at any point of a river. It also adapts itself to the variable heights of water occurring in all rivers through changes of season and of weather, and can easily be brought to shelter if a river is blocked with ice.

We give below a table showing the efficiency of the motor for various sizes, speed of current, depth of

TABLE GIVING DIMENSIONS, EFFICIENCY, WEIGHT, ETC., OF NOSSIAN'S RIVER MOTOR.

Diameter of Wheel, in Meters.	Minimum Depth of Water, in Meters.	Minimum Velocity of River, in Meters, per Second. $v=\sqrt{2gh}$.	Quantity of Water Running through Wheel Channels per Second, in Cubic Meters.	Efficiency in Effective Horse Power.	Dimensions of Pontoons in Meters. Length.	Breadth.	Depth.	Weight, in tons. Of Motor.	Of Pontoons.	Total.	Remarks.
2	1·9	....	3 07	6·5	9	1	1·1	3·2	2·2	5·4	The efficiency in effective h.p. naturally varies with the velocity of current. The latter is, in this table, taken at two meters per second, such as obtains in the Danube Canal at Vienna.
3	2·9	....	7·01	15·0	10	1·2	1·25	4·2	2·8	7·0	
4	3·9	2	13·00	27·0	12	1·3	1·35	5·3	3·2	8·5	
5	4·9	...	19·90	42·0	15	1·45	1.5	6·5	4·0	10·5	
6	5·9	....	29·60	63·0	18	1·7	1·8	8·0	5·0	13·0	

The calculated values upon which the construction of axial reaction turbines is based are not applicable to Nossian's motor, because with the latter, losses from shocks through the formation of whirlpools occur. This loss, notwithstanding the efficiency, amounts to 75 to 80 per cent. of the water passing through the wheel channels $\left(\text{taking } h = \frac{v^2}{2g}\right)$, because the guide wheel, by damming up the water, considerably increases the natural head of water. In this case, the sum of the cross sections of the wheel channel is much smaller than the free surface of the wheel, and v, therefore, is a function of $h + h_1$, and, therefore, $v_1 = \sqrt{2g(h+h_1)}$.

sents its whole superficial area to the current, whose action is thus utilized nearly down to the bottom. By this peculiarity of construction, a higher efficiency is obtained, even with a motor of comparatively small dimensions. The motor, as will be seen from the accompanying illustration, is placed between two wooden or iron pontoons, P, in such a way that it can be raised or lowered at will. It consists mainly of two wheels similar to those used in parallel flow turbines, placed behind one another, and made of sheet iron. Of these, L is the guide wheel and F the working wheel, and both are arranged so as to present their surface to the current, and are carried by the turbine shaft, W, which does not rotate, but is provided with a thrust bearing, K, and stuffing box, and is suspended by the draught rods, Z Z. Rollers, R R_1, at both extremities, allow of a sliding motion along the rails, G G_1, if it be desired to alter the immersion of the apparatus. In order to counteract the pressure of water upon the surface of the guide wheel, which would produce a lateral distortion toward the working wheel, lock chains, H, are used. Some of the blades in the working wheel, F, are fixtures, and serve to connect the outer and inner rims, while other blades are movable, and their position is controlled by means of cranks. All these cranks radiate toward the double ring, V V_1, which can be displaced by means of the forked lever, C, and the draught rod, A. This arrangement effects the necessary displacement of the movable paddles by the draught rod, A, which, in its turn, is actuated by the regulator. The channels of the working wheel open more or less widely, according to the variations of velocity of current, and by the consequent variations of cross section a uniform motion of the wheel is insured. The power is taken off direct from the periphery of the wheel by means of link chains driving on to a lay shaft, connected with the turbine shaft by means of two slide rods in such a way that the motor is adapted to work at any depth. The advantages of the motor may be summed up as follows: It is a reaction wheel, and the angular velocity, and, consequently, also the number of revolutions, is the largest which has ever been reached by a river motor. The well known Girard turbine, and other wheels of water, etc., based upon experiments which were made with one of these motors in the Danube Canal at Vienna, the power being used for driving a dynamo machine.—*Industries.*

NEW GERMAN TORPEDO BOATS.

THE external view given herewith sufficiently indicates the general arrangement of these vessels as seen from the outside.

Officially, the vessels are known as torpedo division boats. They are intended to serve the purpose of guiding a fleet or division of sea-going torpedo boats; and as the conditions laid down to be fulfilled by these vessels are very stringent in their nature, it may not be considered out of place if we here briefly recapitulate the leading requirements of the German Admiralty when placing the contract for the two vessels with Herr Schichau. The vessels were to have the same or even greater speed than the ordinary torpedo boats; they were to be capable of safely riding out any gale; they were to be able to take on board a full inventory of stores and spare gear for the whole division; they were to be fitted with complete workshop arrangements, smiths' fires, etc., to make any necessary repairs at sea; and they were also to be provided with hospital accommodation for sick and wounded. In addition, they were to be armed with torpedoes and quick firing guns to enable them to take an active part in an engagement; to be strongly enough built to ram down a hostile torpedo boat; have as little draught as possible; show little surface above water, so making them all but invisible and giving little target for hostile projectiles. A large coal carrying capacity was to be provided, and the vessels were to be fitted with economical engines to enable them to make long and fast voyages. In a word, it was required that a vessel which should be cheap in first cost, as well as in maintenance, should be capable of accomplishing the same, and even rather more, services than formerly was required from large and costly vessels of the corvette type.

To fulfill all these conditions seemed, indeed, a difficult task, but the German Admiralty placed full confidence in the well proved abilities of Herr Schichau, who has supplied a large number of sea-going torpedo boats to the German and other governments, and last year placed the order for two such vessels with him, the long trials of which have just been brought to a most satisfactory conclusion, all expectations having been fully borne out.

The vessels are 55 meters long by 6·8 meters beam, and have a displacement of 250 tons. Each vessel is divided into 12 water tight compartments, each of which was tested separately during the trials to prove the stability of the vessel. Right forward are placed the torpedo tubes, apparatus for launching the torpedoes, and crew space. Aft of this is the workshop, fitted with all necessary tools and appliances; then follows boiler and engine room. Aft are spacious and handsomely fitted cabins for commander and officers, and a large and elegant saloon buffet and dressing room. The next compartment is taken up by the hospital; then follow cabins for mates and deck officers.

Steam and hand steering gear is provided, and is so fitted as to allow of its being worked from both towers and from the commanding bridge forward of the funnel. Hotchkiss rapid firing guns are placed on the top of each tower and also on the broadsides. The three light masts serve for sailing. The ship is built throughout of the best steel.

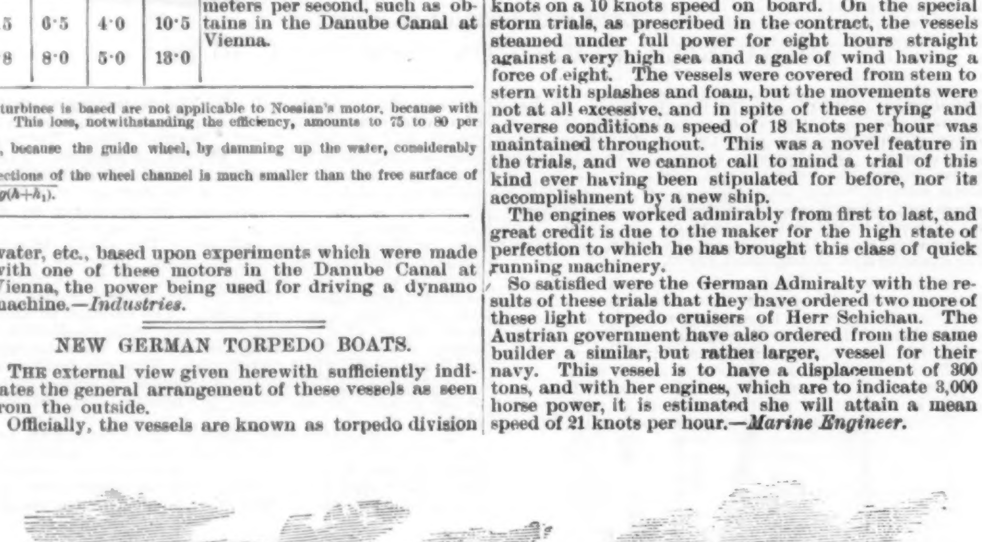
The engines are of the Schichau triple expansion type, working at 270 revolutions per minute, and indicating about 2,000 horse power. There are two locomotive boilers fitted with Herr Schichau's patent firing and ventilating arrangements. These supply all the steam that is necessary for the main and auxiliary engines at a pressure of 12 atmospheres, or say 180 lb. per square inch.

The boilers and engines are completely surrounded by coal bunkers.

On their trial the vessels made a mean speed of 21 knots per hour with full equipment and coal for 2,500 knots on a 10 knots speed on board. On the special storm trials, as prescribed in the contract, the vessels steamed under full power for eight hours straight against a very high sea and a gale of wind having a force of eight. The vessels were covered from stem to stern with splashes and foam, but the movements were not at all excessive, and in spite of these trying and adverse conditions a speed of 18 knots per hour was maintained throughout. This was a novel feature in the trials, and we cannot call to mind a trial of this kind ever having been stipulated for before, nor its accomplishment by a new ship.

The engines worked admirably from first to last, and great credit is due to the maker for the high state of perfection to which he has brought this class of quick running machinery.

So satisfied were the German Admiralty with the results of these trials that they have ordered two more of these light torpedo cruisers of Herr Schichau. The Austrian government have also ordered from the same builder a similar, but rather larger, vessel for their navy. This vessel is to have a displacement of 300 tons, and with her engines, which are to indicate 3,000 horse power, it is estimated she will attain a mean speed of 21 knots per hour.—*Marine Engineer.*



NEW GERMAN TORPEDO CRUISER.

THE MANUFACTURE OF GAS FROM PARAFFIN OIL.*

By W. IVISON MACADAM, F.I.C., F.C.S., Professor of Chemistry, New Veterinary College, Edinburgh.

THE subject that I have the honor of laying before you this evening is one to which, from time to time, we have been called upon to give professional attention. The facts thus obtained have been added to by a series of experiments undertaken during the present session, and the results of which are now laid before the section in the hope that they may aid the general fund of information, which will require sooner or later to be much extended.

Various grades of oil have been destructively distilled; the temperature being carefully regulated according to the class of oil experimented with. The first series of trials were made with:

1. *Crude Paraffin Oil* as obtained from the shale retorts, and without any further treatment. The sample had a specific gravity of 850 (water = 1,000); a flashing point of 92° Fahr.; and a firing point of 106° Fahr.
2. "*Green*" *Oil*, which is obtained from the crude shale oil by a redistilling. The sample had also had the lighter oils (naphthas) removed by fractional distillation. Specific gravity, 884; flashing point, 165° Fahr.; firing point, 193° Fahr.
3. *Twice-run Oil.*—This oil is obtained from the crude oil by distilling (the naphtha not being removed), treating with soda and vitriol, and redistilling without fractionating. The sample had a specific gravity of 802·30; a flashing point of 67° Fahr.; and a firing point of 74° Fahr.
4. *Burning Oil*, obtained from the previous sample by treating again with soda and vitriol, and distilling in fractions. The sample had a specific gravity of 805.
5. "*Crystal*" *Oil*, obtained from the burning oil by retreatment with strong oil of vitriol. Specific gravity, 798; flashing point, 107° Fahr.; firing point, 123° Fahr.
6. *Petroleum.*—This was a sample of ordinary American oil. Specific gravity, 799; flashing point, 84° Fahr.; firing point, 99° Fahr.
7. *Rectified Coal Oil.*—Specific gravity, 844; flashing point, 212° Fahr.; firing point, 235° Fahr. (This and the preceding sample were distilled, so as to compare the results with those obtained from the ordinary mineral oils.)
8. No. 2 *Burning Oil*, obtained by breaking or "cracking" heavier oils. Specific gravity, 830; flashing point, 230° Fahr.; firing point, 250° Fahr.
9. *Intermediate Oil.*—Specific gravity, 846; flashing point, 254° Fahr.; firing point, 280° Fahr.
10. *Intermediate Oil.*—Specific gravity, 868; flashing point, 203° Fahr.; firing point, 262° Fahr.
11. *Intermediate Oil.*—Specific gravity, 871; flashing point, 231° Fahr.; firing point, 286° Fahr.

    (The above three samples of oil were "unfinished.")
12. "*Blue*" *or Lubricating Oil*, from which the solid scale had been removed; the oil receiving no further treatment. Specific gravity, 878; flashing point, 163° Fahr.; firing point, 268° Fahr.
13. "*Blue*" *Oil.*—Specific gravity, 868; flashing point, 270° Fahr.; firing point, 335° Fahr. This sample was specially fractionated from light oils.
14. *Light Lubricating Oil*, freed from scale, treated and redistilled. Specific gravity, 873; flashing point, 270° Fahr.; firing point above 300° Fahr.
15. *Heavy Lubricating Oils*, freed from scale, treated and redistilled. Specific gravity, 250; flashing and firing points, above 300° Fahr.
16. *Gas Oil*, obtained from the acid paraffin tar by distillation. Specific gravity, 828; flashing point, 119° Fahr.; firing point, 134° Fahr.

The crude paraffin oil and "green" oil, as well as the "blue" oils, were run in Keith's or Pintsch's apparatus; the remaining tests being made with the Alexander & Paterson apparatus, which I shall describe more fully toward the close of my communication. The averages of all the results obtained from "blue" oils in Keith's and Pintsch's apparatus are given in separate columns.

The results are stated as follows: (1) Specific gravity of the oil taken at 60° Fahr., or calculated down to that temperature, compared with water at 1,000. (2) Weight of a gallon of the oil calculated from the specific gravity. (3) The number of gallons of oil in one ton by weight. (4) The temperature at which the oil gave off inflammable vapors = "flashing point." (5) The temperature at which the oil became permanently inflamed = "firing point." (6) The amount of gas in cubic feet obtained from one gallon of the oil. (7) The proportion of gas obtained from one ton of the oil. (8) The candle power of the gas, as determined by Bunsen's photometer. (The gas was burned during the testings at the rate of 0·75 cubic foot per hour, and consumed through a No. 0000 burner specially constructed for me through the kindness of Mr. G. Bray, of Leeds. The results were afterward calculated to the value of 5 cubic feet of gas, and are stated in standard sperm candles, each consuming 120 grains of sperm per hour.) (9) Illuminating value of one cubic foot of the gas in grains of sperm. (10) Illuminating value of the gas from one gallon of oil, in pounds of sperm. (11) Illuminating value of the gas obtained from one ton of the oil, in pounds of sperm. (12) The proportion of hydrocarbons absorbed by bromine.

Summary of Results.—The results of the various tests as given in the table show that—

1. The crude oil gave from one gallon 98¾ cubic feet of gas, which is equivalent to 26,026 cubic feet per ton of oil. The candle power was equal to 50⅜ standard candles, or to 4,494 lb. of sperm per ton of oil. Some difficulty was experienced in working this class of oil, as it requires to be liquefied before being passed into the retort. The comparatively large proportion of carbon separated during the distillation renders it impossible to use the Alexander & Paterson apparatus, or any similar works in which the oil requires to flow through tubes. The gas is much more impure than is the case where the semi-refined or refined oils have been distilled; and it is a question whether these very crude oils will prove to be so economical as the purer varieties, and more especially the "intermediate" oils.

2. The "green" oil gave from one gallon 102⅞ cubic feet of gas of 53¼ candle power, and a total value in lighting power per ton equal to 4,741 lb. of sperm.

3. Twice-run oil yielded 106 cubic feet of gas per gallon. The quality was equal to 70 candles, and to 7,105 lb. of sperm per ton. The total amount of gas obtained was 29,605 feet per ton, and is the largest proportion of gas we have yet produced from any oil.

4. Burning oil also gives a high result; being equal to a total production of 27,484 cubic feet of a gas of 63 candle power, and of a total illuminating value of 5,950 lb. of sperm per ton.

5. "Crystal" oil gave 29,928 cubic feet of a 54 candle gas, and a total illuminating value equal to 5,538 lb. of sperm per ton of oil.

6. The American petroleum was most carefully tested time after time; but the quantity of gas obtained was always much below that of the ordinary paraffins. While this was the case, the illuminating value was above that of the home oils; being equal to 66 candles, or a total value per ton of oil of 5,506 lb. of sperm. The average quantity of gas from a ton of oil was 24,110 cubic feet. The difficulty of distillation may be due to the very different chemical composition of the American oil, and the lower temperature required to break up the paraffins which predominate in the American material as compared with the home oils, which contain an excess of the olefines.

7. The total amount of gas from the rectified coal oil was 25,282 cubic feet per ton, and the illuminating power equal to 42½ candles. The total illuminating value was equal to 3,689 lb. of sperm per ton of oil.

8. No. 2 burning oil gave 27,171 cubic feet of a 49¾ candle gas, and a total illuminating value equal to 4,635 lb. of sperm.

9. Intermediate (unfinished) oil of 846 specific gravity gave 24,922 cubic feet of gas. The illuminating power was equal to 60 candles, and the total value to 5,139 lb. of sperm.

10. Intermediate (unfinished) oil of 868 specific gravity yielded 24,383 cubic feet of a gas of 56¼ candle power. The illuminating value of the ton was equal to 4,702 lb. of sperm.

11. Intermediate (unfinished) oil of 871 specific gravity gave 24,396 cubic feet of gas. The candle power was 57⅓, and the total light-giving value equal to 4,822 lb. of sperm.

12. "Blue" oil of 878 specific gravity yielded 32,492 cubic feet of gas, the power of which for illuminating purposes was 54¼ candles, with a total illuminating value of 6,047 lb. of sperm.

13. "Blue" oil of 868 specific gravity gave per ton 33,529 cubic feet of gas, the candle power of which was 54¾, and the total illuminating value 6,295 lb. of sperm.

14. Light lubricating oil, when distilled, yielded 26,273 cubic feet of a gas of 61½ candle power; the total value being equal to 5,521½ lb. of sperm per ton of the oil.

15. Heavy lubricating oil yielded 23,653 cubic feet of a gas which was of 57¼ candle power; the total illuminating value per ton being equivalent to the consumption of 4,643 lb. of sperm candles.

16. Gas oil from acid tar gave 25,963 cubic feet of 43⅓ candle gas, and was equal in value to 3,854 lb. of sperm candles.

While it is possible to employ all these varieties of oil, yet it is principally the qualities intermediate between the burning and lubricating oils that we consider especially interesting. The somewhat large proportion of these oils which are obtained in some works, and the extremely limited demand in the market, has caused much concern to the paraffin oil companies. Various endeavors have been made to limit or altogether do away with the production of these oils, but with limited success. The manufacture of gas seems to me to be one solution of the difficulty; and the large proportion of material obtained, as well as the high candle power, is much in favor of the process. It is doubtful if the retorting of shale for the single purpose of manufacturing an oil for gas making would prove commercially successful, as there is always a heavy loss in the total illuminating value during the crude distillation, as well as in the purifying processes. As illustrating this point, a cannel coal was distilled for gas, with the result that 12,208 cubic feet were obtained of 35·62 candle power. The total light-giving value was equal to 1490·91 lb. of sperm. When distilled for oil, the same coal gave 63·72 gallons of crude material per ton distilled; and taking the gas-making value at 100 cubic feet per gallon, we have 6,372 cubic feet of gas per ton of coal. Against this, however, the candle power was raised to 50, but the total illuminating value was only equal to 1092·34 lb. of sperm per ton of coal. Further, when the crude oil was rectified, the following products per ton of shale were obtained: Naphtha, 1·44 gallons; burning intermediate oils, 22·39 gallons; lubricating oil, 14·87 gallons; and scale, 6·01 gallons—the total of the refined products being equal to 44·71 gallons, with an average specific gravity calculated at 886. Taking the possible gas produced at 100 cubic feet per gallon of oil, we have a total of 4,471 cubic feet of gas per ton of coal. The illuminating value of the gas would be about 55 candles; or a total illuminating value per ton of coal of 843 lb. of sperm, in opposition to 1,491 lb. when the coal was distilled into gas direct. The objection to the above line of argument undoubtedly lies in the fact that a coal of the quality referred to would never be retorted for oil, and that the proper line would be to consider the relative values of shale and the products obtained therefrom. Here we have a new factor to take into account in the very large proportions of ash, and the consequent heavy carriage payable on useless material. I do not presume that it could be seriously thought possible to transmit shale for gas-making purposes to any great distance, or that it will be to any considerable extent distilled for gas direct. The quantity of ash alone would in many cases render it impossible for a gas company to use a material which would leave so large an amount of substance—perfectly useless—to be removed from the works at considerable cost. Again, I say that it is in the use of the less available "intermediate" oils that the true province of gas oils will be found.

One other comparison may be given. It has been proved that when paraffin oil is consumed in lamps as *oil*, there is no difficulty in obtaining from the material a light equal to 27 lb. of sperm per gallon of oil. Now, the total value of a gallon of oil after distillation into gas is only 21·65 lb.; and there is, therefore, a loss equal to nearly 5·5 lb. of sperm per gallon of oil. Doubtless this may be improved upon; but, in the meantime, we are again driven to the use of the cheaper "intermediate" oils—too heavy for consumption in lamps, and too thin in body for lubricating purposes.

In conclusion, I should desire to describe the apparatus employed to obtain the foregoing results. It is the invention of Mr. Paterson, of Messrs. Alexander & Paterson, of Kirkintilloch. The retort is made of cast iron; and the oil is introduced into it by means of pipes carried through the retorts from the front to near the back. During its passage through these pipes the oil becomes vaporized, and is broken up by its after contact with the heated sides of the retort in its return passage to the outlet, which is placed in the front part of the apparatus. The gas is afterward cooled in upright pipes, and, if necessary, it may be passed through the ordinary dry purifiers, and started for use. The permanency of the gas has been frequently tested by myself, and proved to be excellent, and quite equal to any ordinary coal gas. One great advantage the apparatus possesses is its extreme simplicity and non-liability to get out of order. Once started, it works away; and with an occasional glance at the heating apparatus may be continued without trouble for any desired period. My own gas works will manufacture about 80 cubic feet of gas per hour; but, of course, the retorts may be greatly enlarged or increased in number, according to the consumption and production required.

In the course of the discussion on the paper—

Mr. Macadam, replying to Dr. Wallace, said he had not as yet obtained satisfactory results from crude blast furnace tar. He did not think that the Paterson apparatus would give good results with such oils. The figures obtained had been as yet of no practical value, and had therefore not been included in the

	Paraffin Oil.								Paraffin Burning Oil.*			Lubricating Paraffin Oil.*		"Intermediate" Paraffin Oil.*				Paraffin Acid-Tar Oil.*
	Crude Oil.	Green Oil.	Blue Oil.		Rectified Coal Oil.	Twice-run Crude Oil.	Average of Trials with Keith's Apparatus.	Average of Trials with Pintsch's Apparatus.	No. 1 Oil.	Crystal Oil.	American Petroleum.	Light Oil without Scale.	Heavy Oil Free from Scale.	No. 2 Burning Oil.	Unfinished 846 Sp. Gr.	Unfinished 868 Sp. Gr.	Dark 870 Sp. Gr.	
Specific gravity of oil (water = 1000)	850	884	878	868	844	802·30	875·89	877·91	815	798·67	799·27	872·94	894·30	830	846·21	868·68	870·89	828·25
Weight of 1 gallon of oil in pounds	8·5	8·84	8·78	8·68	8·44	8·02	8·758	8·779	8·15	7·98	7·99	8·73	8·94	8·30	8·462	8·686	8·708	8 28
Number of gallons of oil in a ton	263·53	253·39	255·12	258·06	265·40	279·30	255·76	255·15	274·84	280·70	280·35	256·58	250·56	270·00	264·71	257·86	257·21	270·449
Flashing point	92° F.	165° F.	163° F.	270° F.	212° F.	67° F.	289° F.	235° F.	..	107° F.	84° F.	270° F.	+300° F.	230° F	254° F.	203° F.	231° F.	119° F.
Firing point	106° F.	193° F.	268° F.	335° F.	235° F.	74° F.	347° F	354° F.	..	123° F.	99° F.	+300° F.	..	250° F.	280° F.	262° F.	286° F.	134° F.
One gallon of oil gives cubic feet of gas	98·75	102·82	127·42	129·93	95·26	106·00	84·93	97·03	100 00	106·62	86·00	102·4	94·4	100·63	94·15	94·66	94·85	96·00
Cubic feet of gas per ton of oil	26,026	25,977	32,492	33,529	25,282	29,605	21,720	24,757	27,484	29,928	24,110	26,278	23,653	27,171	24,922	24,383	24,396	25,963
Illuminating power of the gas—																		
Five cubic feet are equal to candles	50·36	53·24	54·28	54·75	42·56	70·02	61·36	60·83	63·14	54·00	66·66	61·32	57·26	49·75	60·15	56·25	57·65	43·33
Illumin. value of 1 c. ft. in grains of sperm	1208·64	1277·76	1302·72	1314·25	1021·44	1680·00	1473·00	1459·00	1515·60	1326·00	1599·00	1471·00	1374·00	1194·00	1443·60	1350·00	1383·60	1039·68
Do. of the gas from 1 gallon of oil in pounds of sperm	17·052	18·713	23·714	24·394	13·90	25·44	17·876	20·196	21·65	19 78	19·64	21·32	18·53	17·17	19·416	18·237	18·749	14·25
Do. of the gas from 1 ton of oil in pounds of sperm	4494	4741	6047	6295	3689	7105	4570	5160	5950	5538	5506	5521·5	4643	4635	5139	4702	4822	3853·59
Heavy hydrocarbons (absorbed by bromine) per cent.	..	..	..	..	..	45·5	39·05	38·20	36·82	28·52	27·48	34	30	..	37·5	35·5	35·9	23·36
Carbonic anhydride	..	..	..	..	..	..	0·27	0·08	..	..	..	..	..	..	..	..	..	0·04
Dihydric sulphide	..	..	..	..	..	..	Decided	None	..	..	..	..	..	..	..	..	..	..
Specific gravity of the gas	..	..	..	..	..	..	..	..	600	..	..	..	..	..	..	..	..	..

* Alexander and Paterson's apparatus used

*A paper read before the Glasgow and Scottish section of the Society of Chemical Industry, and reprinted from the Society's *Journal*.

present communication. The rectified coal oil was obtained from the regular coke ovens.

Dealing with Mr. Foulis' remarks, he said there was no doubt that the tubes (small or large) would at first sight appear to a practical man to be a drawback to the apparatus. At the same time he had worked with it for some months past without any choking; and this was probably the best answer to the question. As a matter of fact, the apparatus had been in the hands of practical men for months, and had been found to work with perfect ease. The workmen who were in charge were not skilled or specially trained men, but in all cases the apparatus had given every satisfaction. The tubes were scarcely fixtures. In the retort which he had used for coal testing and oil testing indiscriminately, the tubes were attached to the door of the retort, and could be removed with the door, so that no trouble was experienced in regard to this point.

The quantity of carbon deposited was not so great as might be expected, and it was very seldom that the apparatus required to be cleaned out. But when clearing became necessary, the door and tubes were easily removed. Touching on the use of a jet of steam, he did not include in his paper this method of working, although he had made experiments in that direction, and desired, if permitted, to lay the results before the section at a future meeting. In regard to the question of permanency, the gas had not only been retained for long periods over water, but had also been passed through lead pipes 100 feet in length, which was a very severe test.

The temperature was below freezing point, and the gas was found to be, in proportion to its illuminating value, as permanent as ordinary Edinburgh gas. The tar contained a large quantity of naphthalene; but the proportion of tar was small. He could not say that there was a large proportion of naphthalene present in the gas. During the distillation of the tar from the Alexander & Paterson aparatus, he had a considerable proportion of naphthalene. He was sorry he could not, at the moment, give the cost of 30,000 cubic feet of gas. Of course much depended on the quality of oil to be distilled.

From "intermediate" oils about 24,000 cubic feet of gas could be obtained from a ton of oil. Such oils could be bought at present at 1½d. per gallon, which was equal to about 30s. per ton. The gas was of 60 candle power; so that, roughly speaking, a ton of oil gave gas equal in illuminating value to about 72,000 cubic feet of 20 candle gas. The retorting was certainly not so costly as with coal. For it must be borne in mind that, while the temperature of the retort was much the same as with coals, a great saving would take place in the cost of labor for charging and emptying the retorts, which operations practically ceased to exist when oil was used for gas making. The actual amount of coal should also be less for a given amount of heat, as there was no ash to raise in temperature, as was the case with coals.

American petroleum had proved difficult to distill into permanent gas. The proportion which had been obtained from it was less than with the home oils. No doubt this was due to the difference in the chemical composition of the body, there being in the petroleum more of the true paraffin and less of the olefine group, while in the home oils the olefines predominated. American petroleum required a distinctly lower temperature.

MANUFACTURE OF WIRE ROPES.

THE importance and extent of this industry has been brought vividly before us during a recent visit to Messrs. George Cradock & Co.'s wire and wire rope works at Wakefield. This is an old established and well known firm. Recently, important extensions and additions have been made to their works to meet the increasing demands of business, and at the present time the general arrangement and equipment of this factory afford an excellent example of a modern and efficient wire rope works. Here the entire process, from wire drawing, testing, and strand spinning to closing the finished rope, may be seen in daily operation.

The works occupy an area of about 3½ acres, and are situated on a convenient and accessible site. The buildings are chiefly composed of red brickwork with ornamental iron roofing supported upon light columns. All the structures with their foundations and flooring, etc., are substantially and well arranged, while requisite attention has been bestowed upon the convenient location of the various departments and provisions for lighting, etc.

There are two engine houses, which contain engines of the horizontal Corliss type of 150 horse power each, the former operating the machinery in the core carding, spinning, rope stranding, and closing departments, and the latter driving the wire drawing mill, etc. The engines are supplied with steam by two steel boilers, 7 ft. 6 in. in diameter and 28 ft. long, constructed with corrugated flues and fitted with Green's fuel economizers. The machines are actuated chiefly by overhead shafting and pulleys, motion being imparted to them by cotton rope belting driven by the engine. The strand and rope making shop has an area of about 16,000 square feet, and in it the strand forming and rope closing machines are located. In this shop a powerful overhead traveling crane is provided.

We will now turn our attention to the whole process of manufacture as carried out at these important works. The metal rods from which the wires are drawn are of about 2 to 5 S. W. G., and are commonly rolled at Sheffield and elsewhere from ingots of about 80 lb. each. These rolled rods may be about 130 to 150 yards in length, and after drawing to say a 14 W. gauge, are elongated to about 1,200 yards in length. It must be understood that this is not effected at once, but by a dozen or more separate drawing operations, during which the wire may have to be several times annealed or tempered, for as the process of drawing proceeds, the metal becomes proportionally hardened. In practice, the wire is sometimes returned four times to the annealing pots during the process of drawing down to a small gauge. The metallic rods may be of iron, Bessemer, crucible, or plow steel, etc., and they are sometimes again subdivided into conventional trade names or classes. Test pieces are at first submitted to chemical examination in the laboratory, in order to determine by analyses their exact composition.

After testing, all rods not rejected are passed on for tempering, a process regarded as a trade secret, and as upon it the excellence of the wire largely depends, we are not at liberty to give any definite information on this branch of the manufacture.

After tempering, the rods are taken to the smiths' shop, where one end is heated in a forge and pointed on an anvil, so as to present a tapering point capable of being introduced into the holes in the "draw plates." The rods are then taken to the pickling and washing departments, where they are thoroughly bathed in a dilute acid solution, and subsequently washed with water to remove external grease, dirt, or impurities. These cleansed rods are then dipped into lime water to assist the process of drawing, and afterward are removed to the stock or drying chamber for desiccation. These rods are now ready for the process of wire drawing, and accordingly are removed to this department.

The wire drawing mill consists of a number of horizontal drums called "blocks," arranged to revolve on vertical axes, upon a long counter or table, and by them the rods are drawn through perforated plates held in frames fixed to the counter, and as will be readily understood by reference to Fig. 1, which represents a portion of the mill, with its requisite subsidiary appliances. The drawing pulleys are shown at A, arranged on vertical spindles, B, capable of being put into motion or stopped by convenient known means, and C are cams fixed on the spindles; D are the draw plates held by the clamp frames; E are the pincers for starting the drawing operations.

It will be understood that the pointed end of a rod is introduced into one of the holes in a draw plate, and the portion projecting on the opposite side is laid hold of and pulled by a pair of the pincers, consequently pulling forward its lever attachment. The pulley and spindle are then set in motion, and the rod is drawn through the plate, the pincer lever being forced back by the revolving cam for a distance equal to its throw, when the rod is released and caught hold of again nearer the draw plate, this operation being continued until a sufficient length has been drawn in order to obtain a turn round the revolving pulley. When this is done, the turning of the pulley draws the whole rod through, increasing its length, and of course reducing its diameter, and this process is repeated over a series of drawing pulleys, and through plates with decreasing apertures, until the wire is drawn to the required gauge, the process being facilitated by the application of lubricants known as wire drawer's soap or grease. As before mentioned, after drawing the wire a certain number of times, the properties of the metal become modified, and it has frequently to be annealed.

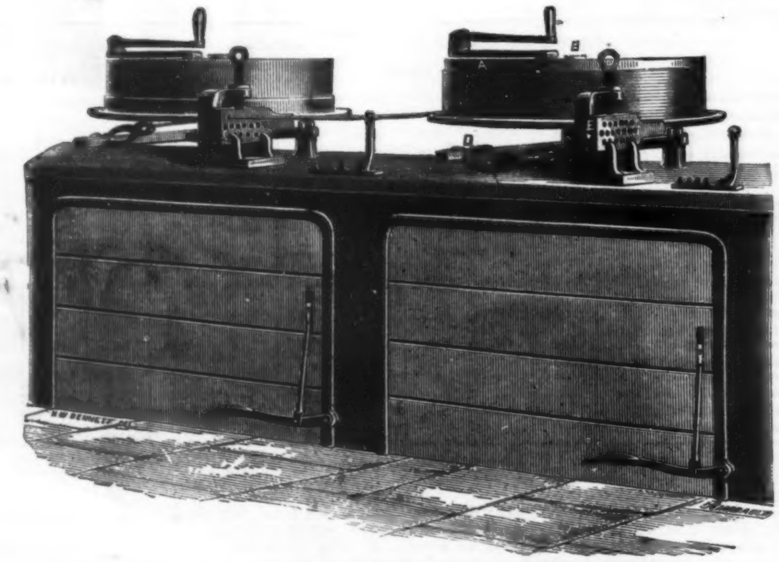


FIG. 1.—MANUFACTURE OF WIRE ROPE.

The successive draw plates are formed with a number of tapering holes of decreasing diameters, the accuracy of which is frequently tried by the insertion of gauge punches. When the holes have increased in size by wear, the plates are heated and hammered up, and the holes partially repunched. It should be understood that the rods or wires are not cut, but simply drawn down, so that there is no appreciable diminution in quantity or weight of metal. The wires having been thus drawn to the required gauges, the bundles are transferred to the testing room, where they are proved for torsional and flexible efficiency and degrees of tensile resistance, by a weighted lever testing machine. Those coils which pass the wire drawers' standard tests are now sent to the wire store of the strand and rope making department.

Here, however, the wire drawers' tests are not finally accepted, for the bundles are subjected to a similar ordeal by the rope makers, thus affording a means of insuring the introduction of only finally approved wires into the manufacture. The thorough and scientific basis upon which this firm conducts its departments, combined with the requisite degree of care to insure that only the best materials shall be used, has rendered their name a guarantee for a first class rope.

It is found that wires of extremely high tensile resistance are not necessary in the manufacture of ropes, but that some of the best results have been obtained with crucible steel wires having a tensile resistance of 80 or 85 tons per square inch of sectional area. Such wires possess a proper proportion of elasticity and toughness. Before describing the actual manufacture of wire strands and ropes, we may refer to the subject of making the cores or centers, which are composed of hemp or wires, according to requirements, in either a simple or compound form, but it is to the former class that we shall now refer. The best Russian hemp, which is here commonly used for this class of cores, is first carded by machinery to extract dirt and extraneous substances, and afterward the fibers are drawn, spun, and warped, in a somewhat similar manner to the process of cotton and flax spinning. The fibers, after being spun into yarns, are thoroughly saturated with tar and subsequently formed into an ordinary hemp rope upon the rope walk, in the usual primitive fashion. It will be understood that in making wire strands or ropes with hempen cores, the latter are fed in centrally, while the wires are twisted or closed around, but they are not supposed to contribute any additional strength.

The method of forming wire strands may now be explained in connection with Fig. 2, which represents one type of strand making machine employed at these works. The selected wires of a requisite gauge—dependent upon the class of strands to be formed—are wound upon the bobbins, A, and placed in the fliers of the revolving frame, B, of the machine. The machine illustrated has six bobbins or wires to the strand, and is a size largely used in the trade. The outer ends of the wires coiled upon the bobbins are passed through apertures provided in the rotary framing to the perforated revolving nozzle, C, and then through the fixed closing block or tube, D, to the draw-off drums, E. The hempen or wire core is drawn into the center of the wires through the hollow shaft, F, of the rotary portion of the machine. As will be seen, the wire bobbins are arranged tandem fashion, and consequently the angle at which the wires are drawn through the nozzle, C, to the closing contrivance, D, is a slight one. This also serves to lay the wires compactly without materially bending or straining them, and further pushes back any slack which may arise from difference of tension on the bobbins, etc. The latter are mounted in fliers controlled by an eccentric motion at the back of the machine, so that while the framing, B, revolves they are always maintained in a vertical position, and thus any individual twisting of the wire is prevented. Each bobbin is mounted on an independent axis and provided with a tension cord and set screw, so that the wires may be paid out uniformly.

The drawing-off drum, E, is driven by a train of gearing, G, actuated by a spur wheel on the revolving portion of the machine, which is proportioned to drive the drum, E, at a certain speed to obtain a required length of lay in the strand, or, in other words, while the bobbins and frame are making one complete revolution, the periphery of the draw-off drum is arranged to receive an angular movement proportional to the lay required. When it is desired to change the lay of a strand, a different arrangement of gearing is substituted. The completed portion of the strand is wound upon a bobbin, H, and is afterward removed and placed in the fliers of a rope closing machine of similar construction to the strand machine already described. When it is required to form strands in a long length, the wires are separately united by brazing or tucking, and in this manner a practically continuous strand of almost any length can be produced.

The process just described refers to the manufacture of a simple or six wire strand, but it will be understood that strands of twelve or eighteen outer wires can be produced by using a similar, but larger, machine.

The wire strands thus formed and wound upon the terminal bobbins are afterward removed to the rope closing machines, which are very similar in construction and operation to the strand forming machine, but are driven at a lower speed. For example, whereas the velocity of the former may be from say 15 to 30 revolutions per minute, the latter attain a speed of about 110 revolutions, and in some types of stranding machines it may exceed 200 revolutions per minute.

Fig. 3 shows one type of rope closing machine used at these works, and represents a very large class of machine designed for closing 24 tons of strands in one continuous length. This has recently been employed in making ropes for the Melbourne cable tramways. These ropes were constructed of patent crucible steel wires, with a circumference of 3⅝ in., and mostly of about 8,300 yards in length, weighing 24 tons 13 cwt., and formed in one continuous piece, without a splice. There are six bobbins in this machine, each capable of holding 4 tons of strand, and when it is fully loaded, the revolving portion weighs about 37 tons. The bobbin frames are shown at A, carried by the shaft, *a*, and in which the fliers, *b*, are arranged for carrying the strand bobbins, B. The action of the fliers is controlled by the crank and eccentric motion, D, so that as the frame revolves, the bobbins are always maintained in their normal or vertical attitude.

The revolving portion of the machine—which, as be-

fore stated, weighs nearly 40 tons—is carried in bearings, E, and upon friction rollers, F. The supporting shaft, *a*, is 8½ in. in diameter, and composed of the best Lowmoor iron. The supporting rollers have axles of Whitworth steel, mounted in phosphor-bronze bearings. The bobbins weigh 8 cwt. each, and are mounted on independent axes, with tension cords and screws, C, so as to insure their running with a desired speed and uniform resistance, otherwise the strands would be irregularly paid out. Motion is imparted to the revolving portion of the machine by a train of gearing, G, operated by a separate engine, having cylinders 12 in. in diameter by 24 in. stroke.

The draw-off motion shown at I is actuated by the spurwheel on the shaft, *a*, for driving the draw-off drum, J. The train of gearing, as also the fixed closing tube or rollers, are, however, omitted in this illustration, as they are practically similar to the arrangements provided in the strand machine shown in Fig. 2, already described. K is the tarring tank; L are brushes for removing superfluous tar; M is a traction pulley; and W a weighted or tension roller. The pulley, M, is driven from the shaft of the drum, J.

It is obvious that a machine of this size cannot be handled by direct manual power, and therefore the hand gearing, H, is provided for turning during the process of placing or removing the bobbins, but which is thrown out of gear when the machine is put into operation. The bobbins, B, are lifted into or out of position by an overhead traveling crane, O, capable of being moved at right angles.

When the loaded bobbins are placed in position on the fliers, the outer ends of the strands are passed through holes in the annular framings, P, to the rotary nozzle, Q; and as the framing, A, revolves, the strands are drawn forward from the bobbins by drum, J, of the stationary part of the machine, and in this manner the strands, W, are twisted round a core, *r*, into a rope, X, between the nozzle, Q, and a fixed tube or roller device or drum, J.

The hemp or wire heart, *r*, is simultaneously drawn forward centrally to the strands, from the reel, R, through a part of the shaft, *a*, terminating with nozzle, Q. S represents an ordinary contrivance for throwing the driving strap, etc., out of gear, when a brake can be applied to the machine. At the commencement the machine is driven at a speed of about seven revolutions per minute, and is gradually increased as the strands run out, and the weight consequently reduced, until a maximum speed of about twenty revolutions per minute is attained.

All the ropes manufactured at these works for running purposes, or ungalvanized wire ropes, are boiled in, or thoroughly impregnated with, distilled Stockholm tar. The usual or old practice of making wire ropes is to twist or lay the wires of the strands to the left hand, and the strands forming the rope to the right hand, and this was once thought absolutely necessary in order to keep the rope together and render it capable of being spliced, etc. Messrs. Cradock & Co., however, manufacture comparatively few ropes of this old construction, as they have introduced and established a new type known as the Lang's patent wire rope, and which promises to supersede all other ropes for aerial transports, winding or hauling purposes. The peculiar feature of this type of rope is that both the wires forming the strands and the strands constituting the rope are laid in the same instead of opposite directions, whereby the component wires are subjected to more uniform work and wear. The appearance of the Lang rope, when new and after wear, and as compared with similar conditions of the old style of rope, is shown in Fig. 4, and from which it may be seen that the new construction does not "break out" at the crown of the strands as in the old form. Ordinary ropes used for winding or hauling purposes are usually broken out, and not worn out, that is to say, they are simply rendered useless prematurely, from local wear confined to the crown of the strands. The degree of novelty in the new rope may be thought by some to be small, but lengthy use has incontrovertibly proved that the practical utility is great.

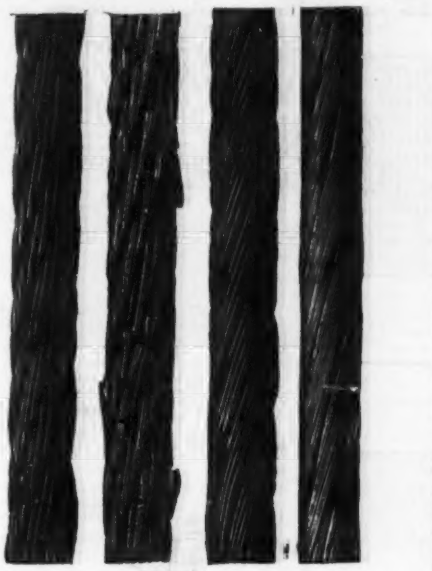


FIG. 4.

At first, the idea of making a rope in which the wires and strands are laid in the same direction was deemed by some as ridiculously unpractical, as it was considered impossible for such a construction to hold together, and much less be spliced. Experience, however, has effectually disposed of these criticisms.

From repeated experiments it has been demonstrated that the Lang rope usually possesses about 10 per cent. more strength, 20 per cent. more flexibility, and 50 per cent. more durability, than ropes of the ordinary or old construction. Ropes composed of six strands of seven or fifteen wires is a frequent construction employed, but the number of wires used varies according to the purposes for which they are required. In cases where great flexibility is desired, numerous wires of a fine gauge are employed. This firm has manufactured the Lang rope up to lengths of about five miles in one continuous piece, and excellent results have been obtained from crucible steel wires, possessing an ultimate resistance of from 85 to 90 tons per square inch. They also manufacture improved plow steel ropes at from 115 to 120 tons per square inch, as the Lang rope allows of a wire of a harder class being used, without the danger of breaking on the crown of the strand. The uniform wear of the wires in a Lang rope is well demonstrated by dissecting the wires of a worn portion of rope, when it will be observed that their cylindrical section has been worn away and wires of semicircular sections remain.

In the manufacture of compound strands or ropes, the lays of the outer wires have an increasing pitch, in order to obtain an equal distribution of the working strains, or to arrange that each wire shall receive a proportional amount of the strains.

We will now refer to some practical applications of these ropes which have come under our notice. During a recent visit to the Clifton Colliery, Nottingham, we inspected Mr. Fisher's system of underground haulage, where a rope by Messrs. Cradock & Co. may be seen at work which has been in constant operation for nearly seven years, as well as others since three and four years, without undergoing repairs. The speed of haulage is 2½ miles per hour, and the endless rope system, operated by Messrs. Fisher & Walker's friction clutch drums, is employed. Here there are several gra-

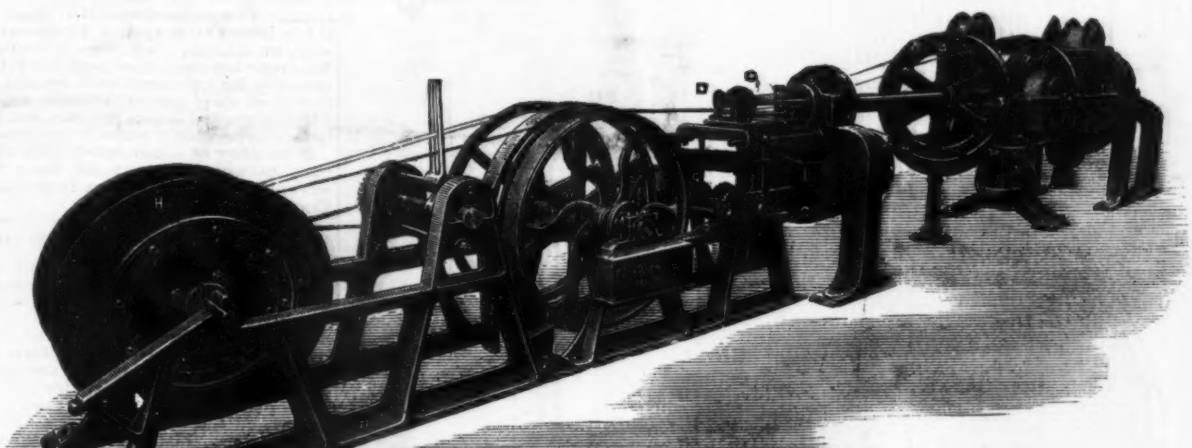


FIG. 2.

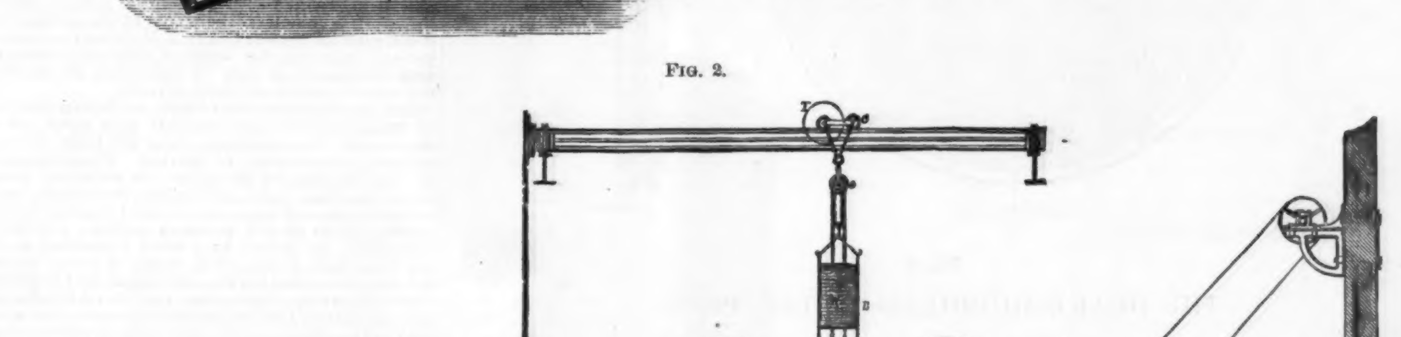


FIG. 3.

MANUFACTURE OF WIRE ROPE—STRANDING AND CLOSING MACHINES.

dients varying from 1 in 4 to 1 in 6, and curves from one chain radius upward. The longest rope is 4,000 yards in length. Two curved portions of line, of five chains radius, on a grade of 1 in 10, exist on a part of the system. Sometimes 80 tubs of 16 cwt. each are hauled, or about 64 tons. The rope-supporting pulleys are of cast steel, varying from 6 in. to 8 in. in diameter, and these last for about three years in constant use. The driving pulleys are 6 ft. and 7 ft. in diameter, and around these the ropes are coiled three times for obtaining driving adhesion. These haulage ropes are of improved plow steel and chiefly composed of wires of 13 B. W. G. The calculated cost of the ropes per ton per mile is about 22d., and the total cost of haulage about 1·6d. per ton per mile. The machinery, appliances, and general arrangements at this colliery are of a first rate character. No practical difficulties have been experienced in splicing the Lang rope.

At the Wollaton Colliery, near Nottingham, we inspected another haulage rope which had been running for about four years. This rope is composed of patent crucible steel wires, and is run at a speed of about three miles per hour, by means of Fowler's clip pulleys. The steepest gradient is 1 in 8. Steel pulleys and rollers are also used at this colliery with satisfactory results. At Messrs. Pope & Pearson's colliery, Normanton, we inspected Lang's ropes employed for winding purposes. These ropes, of plow steel, were making 40 winds per hour, and running nine hours per day. One rope, 1⅝ in. in diameter and 500 yards long, had been in operation for 35 months, and still looked in good condition. This rope raises eight tons per wind, or 500 tons of coal in eight hours, or 1,500 tons per day, if taking into consideration the dead weight of cages and rope, etc. The maximum speed of the winding drum (of about 18 ft. in diameter) is something like 25 miles per hour, and it runs a distance equal to some 18,000 miles per annum. The usual average lives of the under ropes of the old construction were stated to be 17 months, and the over ropes about 20 months. At the Monk Bretton colliery, Barnsley, we examined some winding and haulage ropes supplied by this firm, which had been working for two years and seven months and two years and three months respectively. The winding ropes were 4⅜ in. in circumference, and one was 350 yards long, all composed of improved plow steel wires. A bottom or underside rope had worked two years and four months. About 1,500 tons per day are being raised from this shaft, and the lift of 300 yards is effected in about 30 seconds. During the year 1886, about 250,000 tons of coal were raised at this colliery. We also inspected a haulage rope, 1,700 yards in length and ⅝ in. in diameter, which had been working for two years and three months, running at a speed of 10 to 12 miles per hour. A load of about 18 tons is run in each set. There are some sharp curves and gradients on this system.

We visited the Stanley self-acting surface incline of the Northeastern Railway Company, in Durham, which is 2,350 yards in length. A crucible steel Lang rope of this length and 3¾ in. in circumference, composed of six strands of six wires, formed round a wire core, has been in daily operation here for the past three years and four months, lowering some 5,000 tons of coal and coke daily, or about 1,000,000 tons per annum. The total weight already lowered by this rope has attained the remarkable aggregate of about 3,350,000 tons. This rope is exposed to all kinds of weather, and is continually flagging upon the ballasted road.

Other types of ropes used upon this incline have worked only for about ten months, while some have been rendered useless after six months' use. The working hours of this incline are sometimes from 6 A. M. to 9 P. M.

At the Houghton collieries one of these ropes has been running for thirty-three months, has traveled 27,146 miles, and hauled 488,600 tons of coal. It was afterward used as a tail rope at the Herrington pit for thirty-three months, and hauled 357,500 tons. At the Houghton-le-Spring colliery, Durham, we inspected a similar rope used for driving a pump 2¼ in. in circumference and 5,600 yards long, of improved plow steel, which runs for about eleven hours every night or after raising coal has ceased. This is an endless rope and has been on for over five years, and has pumped about 1,400,000 tons of water and run a distance of about 220,000 miles. The pumping gear is about thirty-eight fathoms below the surface.

At the same colliery we descended the shaft to examine some similar haulage ropes contained in a system of ten miles of ropes for serving workings about three miles from the shaft, the speed of hauling being about twelve miles per hour. The longest Lang rope was 3,000 yards, with a circumference of 2¼ in. And one main rope has worked for two years and eleven months without repairing, and after hauling about 900 tons per day. Ropes employed for underground haulage in collieries are frequently roughly treated, besides working in an atmosphere of coal dust, and often in the wet.

At Messrs. Cradock's works we inspected a crucible steel rope which has recently been removed from the main winning of the Upleatham Ironstone Mines, put on in April, 1881, and removed December, 1886. The number of working days was 1,638, and the amount of ironstone hauled 820,000 tons. This rope, after this period and amount of work, does not appear severely worn.

Our attention was further called to the recent performance of one of these ropes at Meir Hay colliery, Staffordshire. On February 9, 1883, a galvanized plow steel rope, 340 yards long and 3¾ in. circumference, was put in one of the shafts of this colliery, and ran day and night until February 9, 1887, raising on an average 1,800 tons during the twenty-four working hours. The proprietors felt it would be a risk to run it any longer after such a performance, although the rope, to external view, does not appear badly worn. This rope has been now sent back to the works as a curiosity for examination, it having raised during its period of employment 2,630,000 tons. The shaft in which it worked was a wet one, and the water is said to be of a peculiarly corrosive nature.

A number of other interesting examples could be cited in which these ropes have done remarkable work, but space prevents us from extending the list.—*Engineering.*

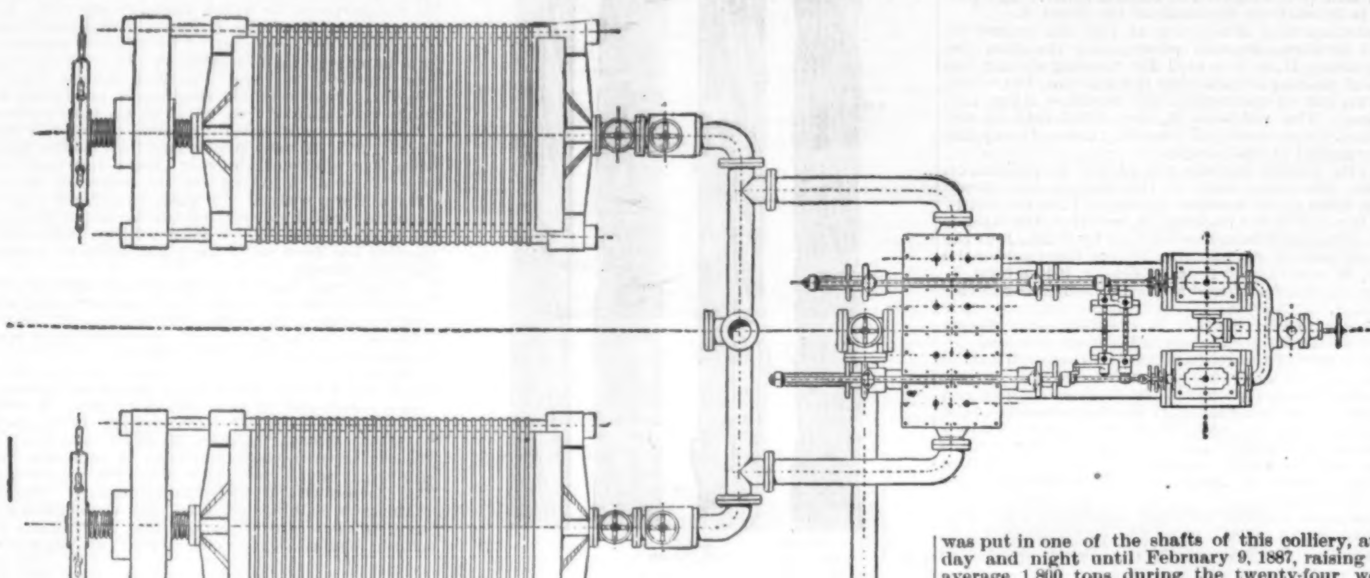


FIG. 1

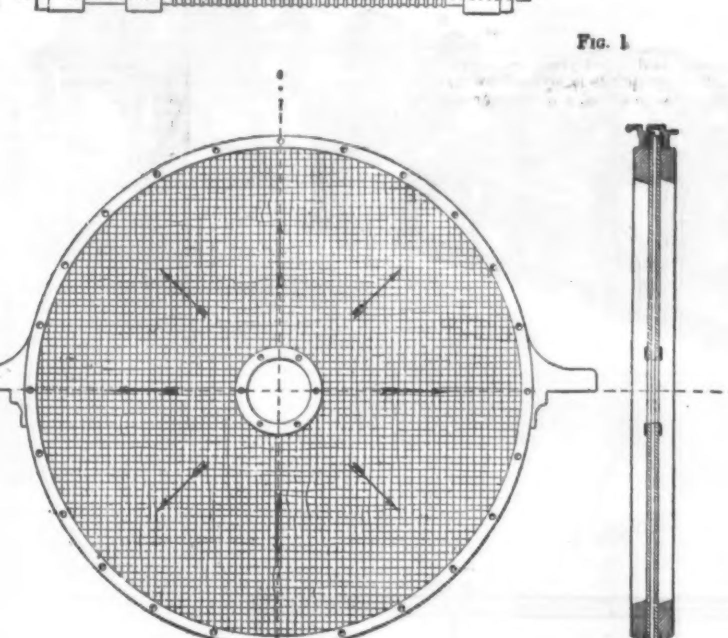


FIG. 2.

THE DRAKE-MUIRHEAD FILTER PRESS.

FILTER PRESS FOR SEWAGE SLUDGE.

THE question of sewage disposal is daily becoming one of great urgency, as was manifested by the interesting and animated discussion which followed two papers recently read at the Institution of Civil Engineers. Messrs. Drake & Muirhead, of Maidstone, have set themselves to solve the problem in such a manner as not only to render the sewage inoffensive and innocuous, but also, by introducing as little extraneous matter as possible, to arrive eventually at a self-contained and continuous process. Entirely on their own responsibility, they dealt with the sewage of Maidstone, a town which now contains 30,000 inhabitants; and success has so far rewarded their efforts, that the corporation of that town have now definitely adopted the system. The two existing precipitation reservoirs are now being relined with granolithic cement, and when this work is complete, the whole of the sewage will be dealt with on Messrs. Drake & Muirhead's system. At present, however, for want of sufficient precipitation area, the system is only in operation at intervals, as the reconstruction of works permits.

The larger extraneous objects are intercepted by one of two cages with bars one half inch apart, let down alternately, like penstocks, into the main sewer, by a suitable arrangement of gearing. These cages, a pair of edge runners for grinding lime obtained from the local limestone beds, and a mixer for making milk—or rather cream—of lime, are driven temporarily by rope gearing from an old portable engine; but they will, eventually, be driven by a small horizontal engine in the filter press house. The cream of lime is allowed to fall into the sewer between the cages, and is well mixed with the sewage, owing not only to its height of fall, and the fact of the sewage flowing over a low weir, but also to the distance (over one hundred yards) which the sewage has to travel before arriving at the precipitation reservoirs. Here the sludge is thrown down, while the liquid portion is allowed to pass into the river Medway, being slightly tinged with yellow, from some refuse liquor now discharged into the sewer from some neighboring paper mills.

From the precipitation reservoir the sludge is pumped up into a storage tank, whence it gravitates, as required, to the hydraulic pumping engine shown, together with the two filter presses, one in and one out, in the annexed perspective view (Fig. 3). This engine pumps the sludge directly, without the intervention of compressed air, thus constituting a very simple arrangement. The engine is duplex; that is to say, the piston of one actuates the valve of the other, and the pistons make a sufficient pause at the end of each stroke to permit the pump valves to close without concussion. The pump valves are simple clacks of cast iron, about two inches thick, shutting down on steel cylindrical seats, and over each valve is a short vertical rod, projecting through the cover of the valve box. These rods can be struck, when necessary, with a leaden hammer, to cut any pieces of wood or other similar obstruction that, having passed the cages, might prevent the valves from closing. In case this

should not be sufficient to remove the obstruction, although it is so in most instances, the valves may readily be exposed by slackening a few nuts, and taking off the valve chamber cover. The engine is direct acting, there being no circular motion whatever, and each steam piston drives two pump rams tandem, as seen from the plan of these pumps (Fig. 1). Plunger pumps have the advantage over piston pumps that the packing is outside and easily renewable, an important matter where gritty sewage sludge has to be pumped. The sludge is thus forced into the filter press, which, as it is remarkably original and effective, demands somewhat minute description. It mainly consists of flanged cast iron rings, alternating with plain wrought iron disks, having, in the center, holes of 5 in. or 6 in. diam. These plates (Fig. 2) are covered on both sides with coir fiber, which has been found the best substance for the purpose. It does not become decayed by the sewage, and, indeed, stands better when damp than when dry, even in pure water. At first, ropes made of this fiber were disposed radially about the disk; then a rope was coiled spirally round the central hole; but now it is found simpler to use disks made of bass matting. The mats are fixed by flat rings surrounding the central hole, and bolted together, and by similar rings at the periphery, or by sewing with tarred twine and copper wire round the outer edge, while the matting is also attached, at intervals in the annular area, to slots in the iron disks, by copper wire. The mats form an efficient filtering medium, but eventually become choked up if used alone; and to counteract this tendency, some kind of sand is used, which seems to keep open the interstices, so that fiber disks so treated last, apparently, for an indefinite period. River or sea sand will answer the purpose; but excellent results have attended the use of two, until now, waste substances, viz., spent foundry sand and old foundry cores ground to powder. It is also found that the compressed sludge itself, when calcined and finely divided, can be used instead of sand, and exerts a useful chemical action on the sludge under treatment, in addition to the mechanical action above mentioned. This substance, indeed, partakes of the nature both of animal and of vegetable charcoal, as will be evident on bearing in mind its chief source of production. It is well known to sanitary engineers that animal charcoal acts upon some constituents of sewage, and vegetable charcoal on others. The sand or powder, from whatever source it is derived, is placed originally between the iron and the coir fiber and also spread over the outer surface. After the plates have been so prepared, all that is necessary is to give them a sprinkling of fresh sand or powder about once a week, to compensate for that which is removed from the surface by contact with the cakes.

The disks, with their matting and sand coating, are placed in position, sliding and resting by their ears on the frame of the press, alternately with the flanged rings, and are pressed together by a horizontal screw, worked by the hand wheel (shown in Fig. 1), which also has holes in its periphery for the insertion of hand spikes, by means of which a very considerable compression may be obtained. On the degree of pressure employed depends the degree of purity to which it is desired to reduce the effluent; and the pressure with which the sludge is forced into the press depends, of course, upon the degree of compression given to the disks. The pumping engine is made to work at a pressure varying between zero and 150 lb. per square inch, which pressure has produced an effluent perfectly inodorous, though still occasionally slightly tinged with yellow, owing to the cause above mentioned. The time occupied by the operation has hitherto varied from thirty to forty minutes, the engine being almost pulled up after half an hour's pumping, when the disks are screwed up as tightly as possible by two men with hand spikes. As shown in the transverse section of the plate (Fig. 2), the flange of one ring overlaps that of the adjoining, thus forming a channel to receive the water, which is forced out radially over the whole circumference. The flanges are, however, interrupted at the bottom, so as to permit the water to flow off into a drain below, and thence into the river. The sludge inlet valve is then closed, and the screw pressure on the disks relaxed, when the press is seen to expand, somewhat like the drawing out of a concertina. Between the disks are found hard, though slightly damp, cakes of compressed sludge, 3 ft. in diameter and about 1½ in. thick. So consistent are the cakes, that they may be removed whole; but they are generally broken into pieces with a crowbar, and allowed to fall into a truck run in below. As taken from the press, the sludge cake has only an odor of vegetable mould; but, when calcined, it is perfectly inodorous.

It will be seen that Messrs. Drake & Muirhead have made a new departure as regards filter presses. The idea has hitherto been to force the substance to be filtered transversely through a comparatively thin layer of filtering medium, which is made into bags or folded up, or, at any rate, pressed against an uneven surface. In the Drake-Muirhead press, on the contrary, the filtrate is forced through the coir fiber in the direction of its length, and for a considerable distance, if its ramifications, due to the weaving of the fiber, be taken into consideration; and the twisting of the fiber in weaving adds still more to the resistance, and, therefore, the filter press gives a high degree of interception, the solid matter being left on the surface and not in the substance of the filtering medium, so that there is no choking up. Moreover, there is no wear, as the disks have a plane surface, leaving no hollows for it to be pressed into and thus expanded, and no sharp edges to cause cutting. Indeed, no fiber disk has yet been worn out or rotted. Two of these filter disks, covered with coir fiber in different ways, were on view in the lecture theater of the Institution of Civil Engineers while the recent papers by Mr. Dibdin on "Sewage Disposal" and Mr. Crimp on "Filter Presses" were being read and discussed. We may add that this system of sludge pressing has just been adopted for the Metropolitan District of Acton.—*Industries.*

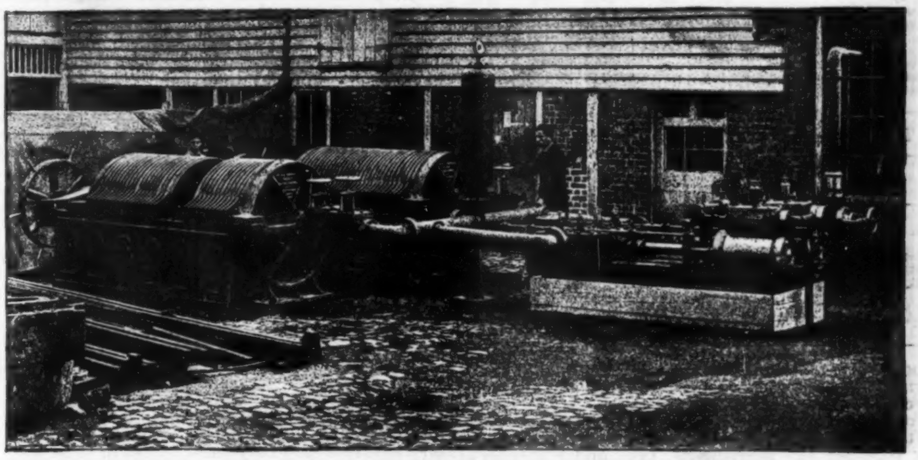


FIG. 3.—THE DRAKE-MUIRHEAD FILTER PRESS.

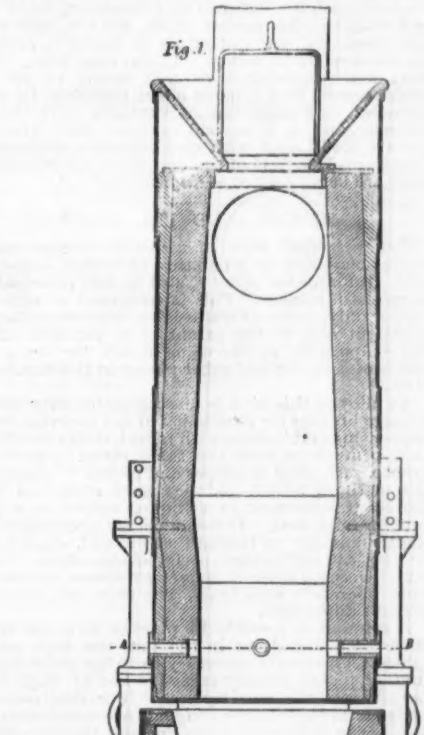
THE HERBERTZ CUPOLA.

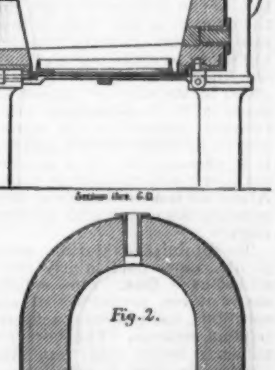
THE Herbertz cupola, which we illustrate on the present page, will strike many as the revival of an old and abandoned idea. But although the salient feature of its operation was proposed and tried years ago, yet the method of applying this principle is so far new that it now results in a success of so marked a character that it is difficult to find a satisfactory explanation of it. In the Herbertz cupola the blast or draught is obtained by a steam jet exhauster placed in a flue near the charging door, while the air is admitted, not by jets or nozzles, but by an annular opening which runs entirely round the cupola just above the hearth. This opening can be increased or diminished in width at will, for the hearth is carried on pillars, and can be raised and lowered upon them by means of screws.

When the opening is narrowed, the blast is rendered sharper, with the effect that the iron is brought down hotter, but in less quantities. On the contrary, when the opening is increased, a greater quantity of air enters with a less velocity. It is at all times possible to watch the working of the cupola, at the slot, as well as the sight holes above it. The mouth of the cupola is closed with a cast iron counterweighted bell, which fits into a seat at the bottom of an inverted cone. In feeding, the broken pigs and coke are put into the cone, and then the bell is raised, whereupon the charge immediately slides down and the bell is replaced, the entire operation only occupying a couple of seconds.

It will naturally be asked how much steam is used in supplying the exhauster. We are sorry that we cannot give exact particulars on this point, but we are informed by Messrs. Tangyes, Limited, who have a 3½ ton cupola at work and are building others, that the expenditure does not exceed that needed to drive a fan to do the same work. On the face of it this result is better than one would have anticipated, and the explanation appears to be that the jet does much less actual work than the fan, for it only maintains a vacuum of about 2½ in. to 3½ in. of water, while the fan gives a pressure of 16 in. to 20 in. of water. Experiments have been made in Germany to determine the consumption of fuel required to raise steam for the exhauster. In one of these, with a cupola melting 3 tons of metal per hour, the coal per hour varied between 8 lb. and 14 lb., which is not more than a fan engine would require. Various other trials gave results which agreed fairly with this. The chief value of the Herbertz cupola to the iron founder lies in its exceedingly small expenditure of fuel for melting the metal.

After several months working in Birmingham, during which careful note has been taken of all the iron and coke used, both for melting and lighting up, it has been found that the weight of fuel only amounts to 6½ per cent. of that of the metal, as against 12 to 18 per cent. in the ordinary cupola. On a special trial, in which the coke for lighting up is not reckoned, a very much lower result can be easily obtained. At the same time,





THE HERBERTZ CUPOLA.

the inventor claims that better and softer castings, with fewer wasters, can be made from the same mixture, or that, if preferred, cheaper pig may be used to obtain a given quality of product. Messrs. Tangyes' experience confirms this contention. An explanation of the great economy of the furnace is offered by Dr. Ad. Gurlt, of Bonn, who has made a series of experiments with the original cupola erected by Mr. Herbertz, at Cologne. He says: "On starting the jet, the metal commences to run down into the hearth in from five to ten minutes, and continues to flow without intermission, and is in a perfectly clean and suitable condition, despite the reduction of fuel to less than one-half the ordinary quantity. This phenomenon is especially remarkable, and calls for a theoretical explanation. The difference in the process of melting in a cupola acting with a blast and in one acting with exhaust steam jet is, primarily, that with the first the air is forced in in a compressed condition, *i. e.*, under a pressure equal to a water column of from 8 in. to 10 in., whereas in the latter it is drawn in in a state of atmospheric density only. The consequence is that the compressed oxygen of the denser air assimilates itself more energetically and more completely with the carbon of the coke with which it meets, forming at once carbonic acid, which, rising in the shaft of the furnace, is partly reduced to carbonic oxide. On account of this reduction to oxide it follows, as a necessary consequence, that a very considerable depression of temperature takes place in the upper part of the shaft, and also an imperfect heating up of the cold materials as they descend to the zone of fusion, representing therefore a heavy loss of fuel by escaping at the mouth in the form of gases of combustion. In the case of the air entering all round under atmospheric tension, the complete combustion to carbonic acid takes place necessarily slower, free oxygen reaches into the upper part of the shaft and causes an elevation of temperature, by which the cold materials are more fully heated and thus enter into the fusion zone in a better condition.

"At the same time, the carbonic acid which has been formed has, before escaping, no opportunity of being reduced to carbonic oxide, and thereby of carrying away unused any of the elements of fuel. Seeing, too, that gray pig iron contains some 2 per cent. of silica, it is evident that the free oxygen reaching into the higher parts of the shaft is enabled to act in the way of oxidizing this material. As a consequence, the iron is fined and softened, and at the same time, by combustion of its silica (as is known by a similar action in the Bessemer process), it acquires a great increase of temperature. It is therefore easily perceived how even the lowest brands of pig iron, such for instance as Luxemburg No. 3, which now stands in the market at 30s. per ton, may yield a very clean and soft casting, as in reality it does, from the furnace under notice. At the same time, the loss from waste (burning) is reduced nearly to *nil*. Herbertz's cupola with exhaust offers, therefore, for casting purposes, very important advantages over the older systems, and it is beyond question that when fully known, it will meet with very extensive employment." There are already 15 of the cupolas in operation and 22 more are being erected.—*Engineering*.

NICKEL AND ITS ALLOYS.

THE principal alloy of nickel is German silver, a triple compound or admixture of nickel, copper, and zinc. But another alloy is also in use, principally for purposes of coinage. This is composed of nickel and copper only, and is of white color, even when the nickel is present only to the extent of 25 per cent. Such is the composition of the coins struck for the governments of Ecuador and other places, at the Birmingham Mint.

An alloy of this kind is more suitable than ordinary coinage bronzes for circulation in hot climates, because copper, in combination with nickel, does not affect the skin so much as does the same metal in the form of bronze. An alloy of copper and nickel, in equal parts, is sometimes rolled, and has been employed by the British Government, to a limited extent, as a substitute for mild steel. These alloys are manipulated in a similar manner to German silver, and, consequently, will not call for further special mention here. The casting of German silver is, in many respects, similar to the same operation with brass, but there are certain important differences.

It is found impossible in practice to make German silver by one melting in the pot, the high and sustained temperature necessary to bring about liquefaction of nickel causing excessive loss of the low melting and volatile zinc (spelter). For this reason the nickel is always alloyed in one operation with a portion of the copper, and the zinc and the remainder of the copper, in the form of brass, are added in a separate melting. It is the invariable rule of English casting shops to make one and one "mixing" and one and one brass. "Mixing," it may be explained, is the name given to the alloy of copper and nickel. This alloy is made in 80 lb. plumbago crucibles heated in a wind furnace, similar to the square section furnaces employed by brass casters, and fed by the best hard coke. It is necessary to use a good coke, since nickel alloys are much deteriorated by contamination with sulphur. About an hour is required from putting in the pot to pouring the metal, and the temperature must be very high.

To diminish oxidation, and also to refine the ingredients, more particularly the nickel, borax is always added as a flux. This substance, though possessing many of the properties of an alkali when in aqueous solutions, has powerful acid properties at temperatures beyond redness. The boracic acid it contains is, like silicic, a feeble acid; but being, like the latter acid, fixed in the fire, it manifests important properties at these higher ranges of temperature, and borax, chemically speaking, contains a more than *normal* quantity of this acid. It will, therefore, be understood how the flux, by inducing a kind of scorifying action, brings about a partial refining of the contents of the pot.

Mixing is run into pigs of a few pounds weight, and each of these should, when cold, present an upper surface somewhat concave, and covered with transverse wrinkles. If the metal show a smooth and bloated convex surface, the presence of impurities, and more particularly of sulphur, may be inferred. The casting of the brass for German silver making differs in no important respect from the ordinary manufacture of the same alloy for sand caster's use. The actual making of German silver begins when the mixing and the brass have been obtained.

TABLE I.—*G. S. as weighed out.*

	Lb. per heat.			Percentages.		
	Copper.	Mixing. (1 & 1.)	Brass. (1 & 1.)	Copper.	Zinc.	Nickel.
"Best best"	8	34	27	55·79	19·56	24·64
"A," "hollow ware"	6⅝	33¼	26⅛	54·97	20·07	24·95
"A"	9⅝	27⅛	33¼	56·87	23·73	19·38
Special 1st (spoon)	10	29	30	57·26	21·73	21·01
1st spoon	11	24	30	58·46	23·08	18·46
1st hollow ware	18	24	21	64·28	16·66	19·05
2d spoon	8	18	40	56·06	30·30	13·63
2d hollow ware	15	18	29	62·10	23·38	14·51
3d spoon & 3d h'ware	8	14	42	56·25	32·81	10·93
4th spoon & 4th h'ware	8	12	48	55·88	35·30	8·82
5th sp'n & hollow ware	10⅝	8⅛	50	57·76	36·10	6·13
"Portland"	7⅝	6	54	55·58	39·98	4·44

TABLE II.—*As analyzed. Results in per cent.*

Quality.	Copper.	Zinc.	Nickel.	Iron.	Lead.
Qual. spec. 4th	56·48	33·11	9·57	0·39	0·49
" " "	56·08	33·55	9·58	0·39	0·36
Sp. 1st spoon	48·17	29·28	21·66	—	—
"B B."	51·44	24·47	23·51	—	—
"B.B."	52·90	20·38	26·06	—	—
3d	64·32	23·98	11·21	—	—
3d "H."	63·34	22·64	13·58	—	—
"A 1"	54·70	20·25	23·67	0·75	0·26

For pig metal, that is, German silver intended for remelting and casting in sand moulds, it is sufficient to mix together the ingredients, fuse under a layer of charcoal, and pour into pig moulds. Sometimes a little tin is added, to give increased whiteness and hardness. It is in the casting of strips for the rolling mill that the special skill of the German silver maker comes in. Many a good brass caster has tried his hand at German silver strip casting and failed, although, to a superficial observer, the two operations are identical. Both alloys, when required in the form of sheets or wire, are cast into strips, or, in the case of wire, into rods, and these are then reduced to the finished form by mere mechanical manipulations.

But a German silver strip, or wire rod, treated exactly as a brass one, would, in ninety-nine cases out of a hundred, result in a sheet or wire, good, perhaps, at one end, but unsound through half of its dimensions. The reason is to be found in the greater shrinkage of the nickel alloy during solidification, and the remedy for this in the careful "feeding" of the ingot during cooling. To compound German silver, of whatever quality, certain weights of mixing and of brass, together with a smaller quantity of copper, are necessary; and to allow for loss of zinc by volatilization during the melting, about 2 lb. of spelter per heat for low qualities, and 1½ lb. for the better qualities, are allowed, the heat being about 80 lb. The ingredients are weighed out, mixed with a certain quantity of scrap, and placed in the pot, which has been already heated to redness. The lumps of new metal are introduced with a pair of tongs, and the scrap by means of a long sheet iron funnel reaching into the furnace. A few pieces of charcoal are now introduced, and the pot covered with a lid.

When the charge has melted, the crucible is stirred with an iron rod, and the zinc allowed for waste is added, the pot being again stirred. Meanwhile the ingot moulds have been prepared, and placed in position. The moulds are similar to those used for brass, and are of two halves, clamped together by rings and wedges. The moulds are cleaned, rubbed inside with oil, and dusted with powdered charcoal (blacking). The caster raises the crucible from the furnace, and, holding it in position, pours the metal into the receptacle, while an assistant keeps back the floating pieces of charcoal with an iron rod.

The mould is now full of German silver, and as the portion in contact with the cool surface solidifies, considerable shrinking takes place, and a hollow core begins to appear at the upper central part of the ingot. The skill of the workman is now brought to bear in supplying a fine stream of metal to prevent the formation of such a core. This stream is continued for some time, and the ingot is thus fed until the last portions form a projecting button at the center of the upper extremity.

Mixing, it may be mentioned, is always made in plumbago crucibles, the charge being diminished in each successive heat, to prevent the corrosive flux acting successively upon the same zone of the pot. German silver is melted in plumbago pots, or in the best fire clay crucibles. The latter are, perhaps, better for the purpose, since they radiate heat with less rapidity, and remain hot for a longer time, a point of some importance when the pouring takes a considerable time, as in filling ingots for wire rods. If the ingots are intended for rolling into spoon strips, the nickel need not be of the very finest quality, because such strips are thick, and destined to undergo only a moderate amount of mechanical strain.

Into metal of this kind, a little inferior scrap, filings, etc., may be introduced, but, of course, it must not be supposed that any rubbish will answer the purposes of the spoon and fork manufacturer. German silver that is destined to undergo the trying operations of raising, deep stamping, or draughting must be compounded of the best brands of spelter, such as "Upperbanks," "D. & Co.," and of best selected copper. The nickel should be either grain nickel or the cake nickel made by the Nickel Company.

A brand of nickel containing varying quantities of copper, imported from Sweden in the form of powder, also gives very good results. Only a limited quantity of the best "raising metal" scrap should be introduced, but this little, if good, has a tendency to improve the working properties, although the reason is not very evident.

The ingots of raising metal are now planed on the flat faces, in order to remove the hard skin and the inequalities which would impair the surface of the finished sheets. Spoon metal is usually not planed. When the metal reaches the rolling mill, it is treated cold, in a similar manner to brass, the first operation being known as "breaking down." The ingots are passed diagonally between very powerful rolls, until they have attained to rather more than the breadth of the required sheet (to allow for trimming) and have, at the same time, of course, increased in length. This treatment is followed by passages longitudinally through smaller rolls.

From time to time, and from the outset, the metal is annealed by heating it in a furnace and cooling with water. After each annealing, the scale must be removed by pickling in dilute sulphuric acid, assisted by scouring with fine sand. Sometimes bright sheets are ordered, and when this is the case, the final pickling is done with aquafortis (nitric acid). The annexed table gives the composition of the various qualities of German silver. "Hollow ware," or "raising metal," it will be noticed, contains proportionally less zinc and more copper than spoon metal or sand caster's pig. The mixtures of the various makers vary a little, some using more copper than others per unit of nickel. The former qualities are somewhat reddish, while the latter have a yellowish tinge.—*Industries.*

THE HARDNESS OF METALS.*

By Mr. THOMAS TURNER, F.C.S., Lecturer on Metallurgy, Mason College, Birmingham.

PART I.

FOR many of the purposes to which metals are applied, the degree of hardness of the material is of the utmost importance. In some cases, as in the preparation of a knife edge, a tool, or a cutting instrument, hardness is much to be desired; while in other instances, where tenacity is required, and the material has to be worked by the tool, special hardness is undesirable. Unnecessary hardness generally leads to loss of time and extra expense in tools, and is often accompanied by weakness and brittleness in the material. Extra softness, on the other hand, is accompanied with destruction of wearing surfaces, blunted edges, and often also with diminished tenacity. A ready method for obtaining trustworthy comparisons of hardness is much to be desired. The usual definition of hardness is somewhat as follows:

"A body is said to be harder than another when it can be used to scratch the latter, but cannot be scratched by it." (Daniell, *Principles of Physics*, 1884, p. 230.) The same writes further states that "hardness is a property that cannot be measured." Though some objection is possible to the latter statement, it is well known that the usual methods of determining hardness are entirely qualitative, and hitherto no accurate system has been proposed by which different degrees of hardness can be satisfactorily compared. The scale of hardness in common use was originally proposed by Moh, and is reproduced here for purposes of reference:

1. Talc 2. Rock Salt	Scratched by finger nail.
3. Calcite 4. Fluor 5. Apatite 6. Orthoclase	Scratched by a knife blade.
7. Quartz 8. Topaz 9. Corundum 10. Diamond	May be roughly distinguished by a file.

We are indebted to Dumas for one of the earliest attempts to classify metals in order of their hardness. (Brande, *Elements of Chemistry*, 1848, p. 534.) In the following list most of the common metals are arranged in order of hardness, depending upon the facility with which they can be scratched by various materials. It may be mentioned that window glass has a hardness of 5·6 on Moh's scale:

Titanium Manganese Chromium Rhodium	Harder than steel Scratch glass.	Platinum Palladium Copper Gold Silver Tellurium Bismuth Cadmium Tin	Scratched by calc spar.
Nickel Cobalt Iron Antimony Zinc	Scratched by glass.		

Lead—Scratched by the nail.

Potassium, Sodium — Soft as wax at 15·5° C.

Mercury, liquid.

Dumas' list, however, is obviously only valuable as a general guide to the variations in hardness between different metals. It makes no claim to quantitative measurement, and even the order of the arrangement is in several instances different to that adopted by later experimenters. In the case of such metals as are used in the arts, and which require to be turned or filed, the workman can judge pretty accurately of the relative hardness by the behavior of the material under his tools. But such experience is of little value for accurate observation, as it has no quantitative value, and will to some extent depend upon the workman's previous experience and the form or character of the tool.

One of the earliest attempts to find a numerical value for the relative hardness of metals was made by the officers of the United States Ordnance Department. (*Reports of Experiments on the Strength and other Properties of Metal for Cannon*, 1856.) In these experiments a punch in the form of a pyramid was used, and was pressed on the metal to be tested with a force of 10,000 lb. The softest metal used for cannon was bronze, and an indentation rather greater than was produced in this material was taken as a standard of comparison. In each case the volume of the indentation was found, and this served as a measure of the hardness. The standard volume was 3·33 cubic tenths of an inch; one-half this volume was described as a hardness of 2, one-tenth the volume as a hardness of 10, and so forth.

* Paper read before the Birmingham Philosophical Society, December 9, 1886.—*Iron.*

The following extracts illustrate the results obtained (Pole, *Iron Construction*, pp. 67, 99, 129):

Bronze	1·36
No. 1 pig iron	2·55
Wrought iron	3·32
No. 2 pig iron	4·15
No. 3 pig iron	6·4
Hardest iron tried	10·1

These results are of great interest, not only as the forerunners of others obtained by later experimenters, with very similar methods, but also as being almost the only quantitative observations of the variations in hardness of cast iron. Other experimenters have been content to speak of "steel" or "cast iron" as if these substances possessed a definite hardness, while we know, as a matter of fact, that their hardness under different circumstances varies over, at least, several degrees on Moh's scale. But it will afterward be shown that the method of indentation by pressure really does not give a correct expression of hardness. The amount of metal displaced by a given force will evidently depend, to a considerable extent, upon the tenacity of the material, and so the results quoted above must depend upon the resultant of at least two properties, and are, therefore, not correct expressions of relative hardness. (For proof of this, see Part III.)

Hardness I understand to be the property whereby a body is enabled to blunt or wear away the edge of a tool used upon it. In this it differs from tenacity, which though increasing the force necessary to be employed in cutting, does not wear away the edge of the tool. At a later stage it will be shown that, with the metals in a state of purity, tenacity and hardness accompany each other; but this is not the case in alloys or in the various commercial varieties of iron. In 1859 Messrs. Calvert & Johnson published a very interesting series of results of experiments on "The Hardness of Metals and Alloys" (*Philosophical Magazine*, 4th series, xvii., p. 114). The method employed was in reality only a modification of that previously described, though the authors appear to have been unaware of the American experiments. A graduated bar terminating in a steel point was pressed by means of a weighted lever upon the surface to be tested. The point used was conical, being 7 millimeters long, 5 millimeters wide at the base, and 1·25 millimeters wide at the smaller end. The weights were added so as to cause the point to enter the metal operated upon 3·5 millimeters in half an hour. A number of common metals were tested, and also five pretty complete series of alloys. Some of the more important results are as follows:

Staffordshire gray iron (No. 3)	1,000	Silver, pure	208
Steel	958(?)	Zinc	183
Wrought iron	948	Gold	167
Platinum	375	Cadmium	108
Copper (pure)	301	Bismuth	52
Aluminum	271	Tin	27
		Lead	16

In connection with alloys, it was shown that in the zinc-copper, tin-copper, and lead-tin series, the hardness was greater than that calculated from a mixture of the constituents, this being especially noticeable in the copper-zinc series. In the tin-zinc series, on the contrary, the hardness observed was slightly less than that calculated. In considering these experiments, the objection previously mentioned in connection with the American results must be urged, that it is doubtful if the weight necessary to drive a punch a given distance into the metal would not depend at least as much upon the tenacity as upon the hardness. With this special form of experiment there is the difficulty of making the punch enter exactly 3·5 millimeters in just half an hour, and also the fact that in a number of cases the specimens operated upon broke under the pressure, sometimes even before the point had entered at all. Of the general accuracy of the observations themselves, however, we have proof in their agreement with similar experiments by Bottone. Bottone (*Chemical News*, 1873, xxvii., p. 215) also appears to have overlooked the results of previous workers in this direction. Two methods were employed in his determinations, the first identical with that of Calvert and Johnson, except for an improved method of applying the pressure to the steel cylinder which was made to indent the metal to be tested. The second method Bottone considered perhaps less exact, and was used in the case of brittle metals. A soft iron disk rotating with an invariable velocity was pressed with a constant force against the metal to be tested. The time necessary to produce a cut of a definite depth was taken as a measure of the hardness of the material. The results may be expressed as follows:

Manganese	1,456	Gold	979
Cobalt	1,450	Aluminum	821
Nickel	1,410	Cadmium	760
Iron	1,375	Magnesium	726
Copper	1,360	Tin	651
Palladium	1,200	Lead	570
Platinum	1,107	Thallium	565
Zinc	1,077	Calcium	405
Silver	990	Sodium	400
Iridium	984	Potassium	230

Diamond 3,010.

Bottone concluded that the hardness so obtained was proportional to the specific gravity of the metal divided by its atomic weight, and gave a number of examples to prove this statement. To these experiments we have to urge the objection brought against other determinations by a similar method, namely, that the depth of the indentation produced would depend upon the combined tenacity and hardness of the material. It will be found on comparison of the results of Calvert and Johnson with those of Bottone that in those cases where the same metals have been separately examined the order of hardness is very similar. This is illustrated in the following list:

Calvert and Johnson.		*Bottone.*	
Iron	948	Iron	1,375
Platinum	375	Copper	1,360
Copper	301	Platinum	1,107
Silver	208	Zinc	1,077
Zinc	183	Silver	990
Gold	167	Gold	979
Cadmium	108	Cadmium	760
Tin	27	Tin	651
Lead	16	Lead	570

It will be seen, however, that the quantitative values of the hardness given by the two series of experiments are very different. Thus, as examples, we have the following approximate values:

$$\text{Calvert and Johnson} \ldots \frac{Fe}{Cu} = 3 \quad \frac{Fe}{Pb} = 58 \quad \frac{Pt}{Zn} = 2 \quad \frac{Cd}{Sn} = 4$$

$$\text{Bottone} \ldots \frac{Fe}{Cu} = 1 \quad \frac{Fe}{Pb} = 2\tfrac{1}{2} \quad \frac{Pt}{Zn} = 1 \quad \frac{Cd}{Sn} = 1$$

It is obvious from these values that the numbers given to represent the hardness of the different metals are only correct under the circumstances of the experiment. An interesting question arises as to the cause of the marked difference in the numerical values obtained. The explanation is probably to be found in the fact that in Calvert and Johnson's experiments the weight was gradually applied during a space of half an hour. As a natural consequence plasticity is an important factor, and the plastic metals—tin, lead, and cadmium—yield very low values. Bottone appears to have applied his weights more rapidly, and naturally obtained higher values. Reference has been made to the fact that the force required to make a given indentation would depend, at least in part, on the tenacity of the material. It is, therefore, interesting to compare the hardness results previously quoted with the tenacity of the same metals as given by other observers. In 1809 M. Guyton-Morveau published the results of experiments on the tenacity of the common metals as measured by the weight in kilos supported by a wire 2 millimeters in diameter. (*Annales de Chemie*, 1st series, lxxi., p. 189.) To the nearest whole number his results are as follows (p. 194):

Iron	250	Gold	68
Copper	137	Zinc	50
Platinum	125	Tin	16
Silver	85	Lead	6

A much more extensive series of experiments was performed in 1841–44 by M. G. Wertheim (*Ann. Chim. et Phys.*, 3d series, xii., page 385; xv., page 114). In the following table is given the tenacity of the commoner metals, the values being in kilogrammes per square millimeter. In each case the metal was annealed, and used in the form of wire, the weights being added quickly:

Iron	50·3	Gold	11
Copper	31·6	Cadmium	4·8
Platinum	26·7	Tin	3·6
Silver	16·4	Lead	2
Zinc	14·4		

It is interesting now to compare the results of the different observers. This is done in the following table:

	Hardness.				Tenacity.			
Moh's Scale.	Calvert and Johnson.		Bottone.		Guyton-Morveau.		Wertheim.	
5	Iron	948	Iron	1,375	Iron	250	Iron	50·3
5–4	Platinum	375	Copper	1,360	Copper	137	Copper	37·6
3–2½	Copper	301	Platinum	1,107	Platinum	125	Platinum	26·7
3–2½	Silver	208	Zinc	1,077	Silver	85	Silver	16·4
..	Zinc	183	Silver	990	Gold	68	Zinc	14·4
3–2½	Gold	167	Gold	979	Zinc	50	Gold	11
..	Cadmium	108	Cadmium	760	—	..	Cadmium	4·8
2	Tin	27	Tin	651	Tin	16	Tin	3·6
1½	Lead	16	Lead	570	Lead	6	Lead	2

An examination of this table shows that according to the experiments referred to, the order of the common metals for hardness and tenacity is practically the same. It has previously been mentioned that Bottone stated the hardness of the common metals varied as the specific gravity divided by the atomic weight. But Wertheim had stated thirty years earlier that the tenacity of a metal varied as the specific gravity divided by the atomic weight. It will be seen that what Wertheim first stated to be the case in relation to tenacity Bottone quite independently afterward claimed to be true of hardness. The fraction

$$\frac{\text{atomic weight}}{\text{specific gravity}}$$ we know as the "atomic volume," hence

$$\frac{\text{specific gravity}}{\text{atomic weight}}$$ will vary inversely as the atomic volume,

or, in other words, as the number of atoms in a given space. Hence the statements of Wertheim and Bottone, if true, would show that both hardness and tenacity vary directly as the number of atoms in a unit space. It has been previously stated that the method adopted in the determinations of hardness depended—at least to some extent—upon both tenacity and plasticity, and it is doubtful to what extent the method of experiment affected the close agreement between the order of the metals for tenacity and hardness. But in spite of this defect there can be no doubt that the hardness of the common metals does agree pretty closely with their tenacity, and that these vary in some measure with the atomic volume. It has been suggested that in attempting to measure hardness and tenacity, we are really only trying to measure the same force by two different methods. Such an idea is incorrect. Doubtless both hardness and tenacity depend upon cohesion, and this, again, upon the number of molecules in a given space; but, nevertheless, hardness and tenacity are distinct physical properties. For instance, in the case of cast iron special hardness is not accompanied by high tenacity; on the contrary, the tensile strength of a hard iron may usually be increased by rendering the metal softer.

Probably a good example of the difference between tenacity and hardness is furnished in the case of a sandstone. Such a material, owing to the hardness of its particles, rapidly wears away the edge of a tool used in working it, while the tenacity is often very low. We see, therefore, that tenacity depends on the strength of the material, as a whole, while hardness varies with the tenacity of the particles of the mass. When the tenacity is uniform throughout, or, in other words, when the material is perfectly homogeneous in structure, tenacity and hardness vary together directly as the number of physical atoms. (I use the expression "physical atom" to express the idea that the atom of the physicist and chemist are not identical.) Hence in the common metals, which are homogeneous, we find tenacity and hardness follow in the same order, and apparently depend upon the same cause. It may be noted that the metal which is least regular in this respect, viz., zinc, is also the most crystalline. Also that annealing, which diminishes the density of a metal, decreases its tenacity and hardness; while the density, tenacity, and hardness increase together by hammering or cold rolling. In the case of the vast majority of substances, however, some definite crystalline or other structure is met with, and the material corresponds more or less closely to the example of the sandstone previously mentioned; consequently, tenacity and hardness do not follow according to any such simple rule as that above given. Accepting these statements as correct, it follows that, in any trustworthy method of determining hardness, the results obtained should closely agree with the tenacity in homogeneous substances, while in non-homogeneous materials it should not follow according to any definite rule.

CONCLUSIONS.

1. That hardness and tenacity are distinct physical properties.

2. That methods for the quantitative determination of hardness depending on the production of an indentation of considerable size have the following disadvantages:

a. The results are influenced by the tenacity of the metal.

b. Owing to plasticity, the results vary according to the time taken to produce the indentation.

c. Brittle substances are apt to be broken by the pressure.

3. That in substances which are homogeneous in structure the hardness and tenacity generally vary according to the number of atoms in a given space.

4. That in substances possessing a definite structure the above rule does not hold good.

(To be concluded.)

POWER REQUIRED FOR FLOUR MILLS.

THERE is a wide diversity in the opinion and practice of millwrights as to the power necessary to drive a modern built mill on the roller system with the numerous paraphernalia. The old rule of 15 horse power per run of stone does not apply, and no sufficient number of tests have been made to demonstrate conclusively what may be adopted as a general rule. The American *Milling Engineer* says: We have made several careful tests, in order to settle the question, if practicable, within comparatively narrow limits, and have noted other tests. The range so far found has been from 0·5 horse power per barrel of daily capacity in small mills to 0·35 horse power per barrel in mills of 250 barrels and larger capacity. These figures we know to be accurate in so far as the individual mills from which they are obtained are concerned, and we believe them to be a safe guide to follow. Yet, in a recent conversation with a prominent mill builder, he remarked that he could not understand how so much power was required, as he invariably used smaller engines than his competitors, and had no trouble. While this may be true, it does not follow that the use of the smaller engines has been profitable for his customers. The rated horse power of steam engines, especially automatic engines, is no criterion by which to judge the power developed in use.

In an automatic engine, the power developed varies with each change in the load; and if the load increases, or is larger than the rated power of the engine, the power developed will increase, limited only by the conditions of speed of piston and boiler pressure. Take a Corliss engine, for example, rated at 100 horse power, with steam at 80 lb. boiler pressure, and cutting off at one-fifth stroke, and running at eighty revolutions. This engine, according to the recorded tests, would drive a 250 barrel mill under the above conditions. It will also drive a mill of double the capacity, provided the speed or boiler pressure, or both, be increased, or the point of cut-off be carried along to one-half stroke, with the engine every other revolution taking steam full stroke; but when it is doing this, it is developing more than 100 horse power, and is not doing it economically. If the speed is increased, the engine will wear out quicker; if the boiler pressure is increased, the strain and consequent wear and tear on the boilers will be greater; and if speed and boiler pressure be kept the same, the engine will work nearer like a slide valve, and the advantage of working the steam expansively will be lost in great measure, with a consequent loss in economy in fuel.

COMPOSITION OF MERCURY.

SINCE my first paper on the probable composition of mercury I have noticed other relations between that metal and gold and thallium which are interesting, and if not accidental, may possibly lead to the discovery of an important law.

The atomic weights and specific gravities are those previously given, and are the most recent determinations I have been able to obtain:

	Specific gravity.	At weight.	At. vol.
Gold	19·263	196·2	10·181
Thallium	11·86	203·6	17·167
Mercury, liquid	13·598	200·0	14·708
" solid	14·39	.....	.....

It will be seen that not only is the atomic weight of mercury the mean of that of gold and thallium, but its specific gravity in the liquid state is very nearly the mean of their atomic volumes; and its own atomic volume when fluid is almost exactly the theoretical specific gravity of an alloy formed from equal weights of gold and thallium, the calculated specific gravity being 14·68, which is only 0·29 in excess of the specific gravity of solid mercury, being less than the difference in the calculated and actual specific gravity of some known alloy, one of gold.

A. C. COUSENS.

EIGHT LIGHT DYNAMO.

By GEO. M. HOPKINS.

UNFORTUNATELY for the tyro in electrical matters, no rule or set of rules exists in the literature of dynamo electric machinery which would enable him, with entire confidence of success, to plan a new form of dynamo, or even to attempt to construct any one of the well known forms. The available information generally fails in some minor details, thus, in some degree, obscuring the whole subject, and awakening doubts as to the best course to pursue. One might follow such information as closely as possible, and proceed so far as to make an operative machine, and yet it might happen that no current could be evoked from it, simply for the want of specific knowledge as to how to secure the first increment of magnetism necessary for starting the inductive process.

The writer knows a case in point where good workmanship, proper proportions, and correct connections failed of giving any results whatever. Naturally, rewinding was resorted to, but to no purpose. Other experiments were tried, with no better results. But, finally, acting upon a hint given by a builder of dynamos, the maker of the machine was out of his difficulty almost in an instant.

It is not the purpose of the present paper to treat on dynamos in general, but to give, as fully as possible, specific information as to the construction of a small dynamo electric machine capable of supplying a current for eight sixteen-candle power incandescent fifty volt lamps, or a larger number of smaller incandescent lamps of suitable resistance, or an arc lamp of ordinary power. The armature speed is 2,200 revolutions per minute, and the machine running normally requires one horse power to drive it. The machine weighs 130 pounds, and occupies a floor space of 8 × 18 inches.

The dimensions of the machine are tabulated below:

Height of field magnet	18	inches
Length of field magnet waist	6⅞	"
Width of field magnet waist	5⅜	"
Thickness of field magnet waist	1⅝	"
Depth of polar extremities from waist to base	4½	"
Width of polar extremities	6¾	"
Thickness of polar extremities	3	"
Diameter of bore of polar extremities	3⅝	"
Thickness of yoke	1⅞	inches
Diameter of bolts passing through the yoke	⅝	"
Length of armature shaft	18	"
Diameter of armature shaft	⅝	"
Diameter of armature shaft bearings	½	"
Length of parallel faces of armature	6¾	"
Diameter of iron rings of armature core, outside	3	"
Diameter of rings of armature core, inside	1⅞	"
Thickness of rings	1/16	"
Number of iron rings on armature core	39	
Diameter of wooden armature core	1⅞	"
Length of wooden armature	6⅝	"
Length of armature core	6⅝	"
Number of divisions of the armature core	24	
Number of divisions of the commutator cylinder	24	
Length of commutator cylinder	2	"
Width of brushes	11/16	"
Size of wire on armature, No. 20 Am. W. G.	0·032	in. diam
Length (approximate) of wire in each armature coil*	25	feet.
Number of convolutions in each layer	8	
Number of convolutions in each coil	16	
Number of layers in each coil	2	
Number of coils in each space of the armature	2	
External diameter of armature	3⅜	inches
Weight of wire on armature	2¼	pounds
Diameter of pulley on armature shaft	3½	inches
Width of pulley on armature shaft	2½	"
Width of driving belt	2	"
Size of wire on field magnet, No. 18 Am. W. G.	0·040	in. diam
Number of parallel wires on each leg of field magnet	4	
Number of layers of wire on each leg of field magnet	8	
Number of layers for each wire	2	
Weight of wire on field magnet	12	pounds

* This quantity varies a few inches with the different coils.

The field magnet is made of two like parts of soft, gray cast iron, joined at the center of the yoke, and bound together by two bolts, as shown in Fig. 1. The adjoining surfaces of the yoke are accurately faced, so that when clamped together, the connected halves of the magnet will be practically the same as if made integrally.

The bore of the polar extremities of the magnet is 3⅝ inches in diameter, and the sides of the magnet around the bore are faced in the lathe to form a true support for the bronze yokes supporting the ends of the armature shaft. These yokes are bored to receive the armature shaft, and faced in the lathe upon the surfaces abutting against the sides of the magnet. The yokes are secured in their places on the magnet with their centers coincident with the axis of the bore of the magnet.

The armature shaft is fitted so as to revolve freely on its bearings, and there is a clearance between the periphery of the armature and the magnet of about one-eighth inch.

Upon the portion of the armature shaft lying between the poles of the field magnet is placed the cylin-

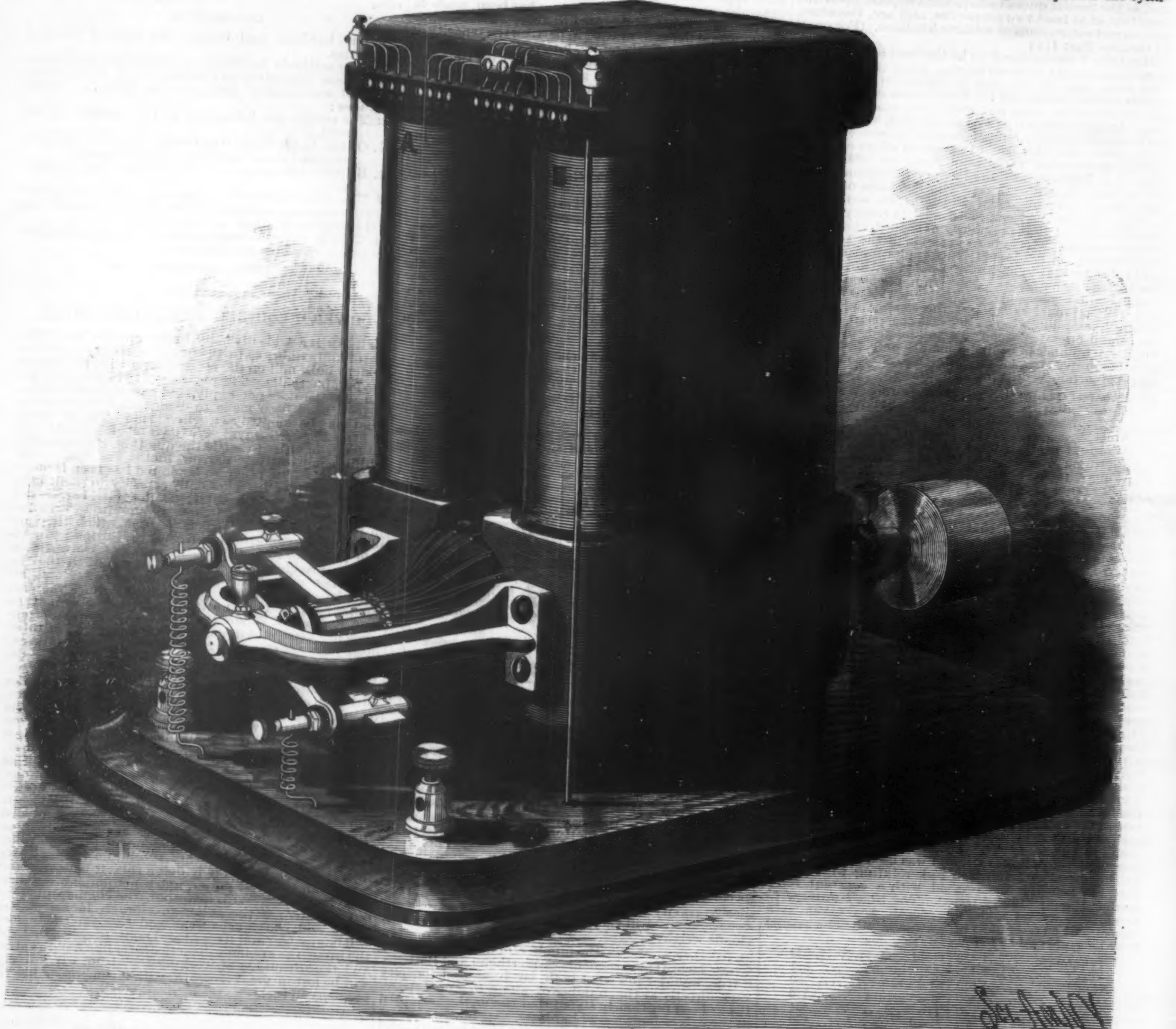


FIG. 1.—EIGHT LIGHT DYNAMO.

der, of thoroughly seasoned hardwood of the size above given. Upon this wooden cylinder are placed the thirty-nine iron rings or washers, with intervening paper rings of the same size and about one thirty-second inch thick. The iron rings are drilled at diametrically opposite points to receive the brass rods by which the entire series is held together. These rods are each inclosed throughout their entire length in a tube of hard rubber or paper, and the nuts on opposite ends of the rods are separated electrically from the end washers by washers of insulating material, such as mica, vulcanite, or vulcanized fiber. The arrangement of the parts of the core of the armature is shown in Fig. 2, in which some of the iron rings have been separated, to more clearly illustrate the construction.

The series of iron rings is secured to the wooden cylinder and the shaft by two pins passing through the rings, the wooden cylinder, and the shaft.

The edges of the end rings are rounded, to prevent them from cutting the insulation of the wires. In two of the rings, at each end of the armature core, are formed twenty-four equidistant radial slots, *b* (Fig. 3), one-eighth inch deep and one-sixteenth inch wide. The armature core thus formed is covered over its entire

surface with adhesive tape, such as is commonly used by wire men for covering joints in conductors. The tape is wound spirally on the periphery of the core, and is arranged radially on the end of the core. It is also wound spirally upon the shaft one and three-eighths inches in each direction from the ends of the armature core. Into the radial slots, *b*, are driven small wedges, *a*, of hard rubber, which are allowed to project three sixteenths inch beyond the periphery of the core.

The winding of the armature is most readily done in

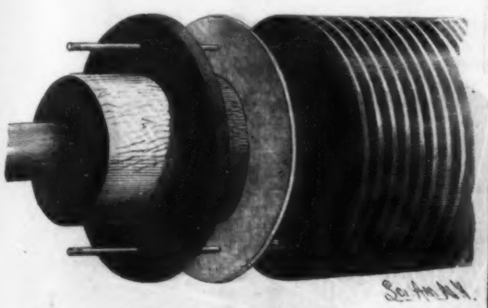


FIG. 2.—PARTS OF ARMATURE CORE.

a lathe, as shown in Fig. 3. The armature shaft with a dog attached is supported between the centers of the lathe, with dog in engagement with the face plate. A spool of No. 20 wire* is supported in a convenient position at the back of the lathe, and after bending the end of the wire around one of the wedges, leaving about 4 inches projecting beyond the wedge, the winding is begun. The wire is carried by one hand along the surface of the armature core and through the space between two wedges at the opposite end of the core, corresponding with the space in which the coil was started. The other hand grasps the face plate of the lathe, and as the wire is carried across the end of the armature core, the face plate is dexterously turned through a half revolution, bringing the opposite side of the core uppermost. The wire is then laid between the two pairs of wedges diametrically opposite those embracing the wire on the other side of the armature. The wire is carried across the commutator end of the armature core, and the armature is returned to the position of starting by returning the face plate to its first

FIG. 3.—METHOD OF WINDING.

position, and the wire is laid alongside of the portion first laid on. The wire is carried lengthwise around the armature in this manner until eight parallel convolutions have been laid on. This layer of wire will extend across the space between two of the wedges. In Fig. 4 the inner layer, B, is represented as being raised from the core, to more clearly show the position of the wire on the armature, and the inner and outer coils are widely separated; but it will of course be understood that these wires are to lie as closely as possible to the core in the working machine. The beginning or inner terminal, E, of the coil, B, is represented in black. In practice, this end of the wire is always coated with colored varnish as soon as the coil is complete, and before the two ends of the coil are twisted together, as they always are temporarily, for convenience in winding, so that there cannot be a mistake as to which are the inner and outer ends of each coil.

After winding the inner layer of the first coil, the winding is continued, forming the outer layer, D, on top of the inner layer, by winding in the same direction, but returning by the successive coils of the second layer toward the point of starting. When the outer layer is complete, the wire is cut, leaving a projecting end about 4 inches long. The colored or inner end of the wire is now twisted with the outer or uncolored end. In this manner, the first coil is placed in the spaces 1, 1, of the armature. It will be observed by reference to Figs. 4 and 5 that the two halves of each coil are arranged across the end of the armature on opposite sides of the shaft. This secures a compact end and a minimum amount of dead wire.

After placing one coil in spaces 1, 1, in the manner described, spaces 2, 2, are filled in the same way, then

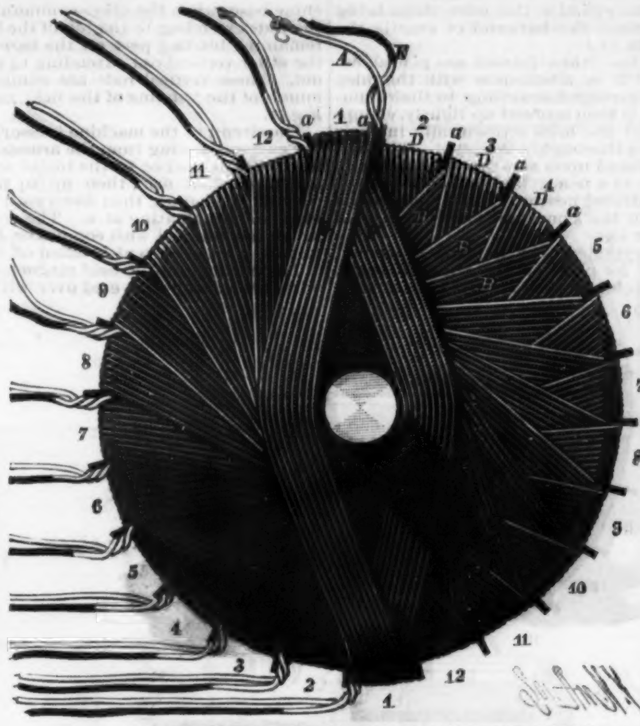


FIG. 5.—STARTING THE OUTER SERIES OF COILS.

3, 3, and so on, until twelve coils are wound upon the core. These coils half fill all of the pairs of spaces 1, 1, 2, 2, 3, 3, etc., to 12, 12, with terminals, A, E, projecting from each space around one-half of the periphery of the commutator end of the armature, the end of the armature presenting an appearance which would be indicated by Fig. 5, if the coils, G F, were omitted. When the armature is half filled, the winding is continued in exactly the same manner and in the same direction as before, forming a coil of two layers, F, G, in spaces 1, 1, on top of the first coil, B, D, leaving projecting terminals, as in the case of the first series of coils. Then a similar coil is formed on top of the coil in spaces 2, 2, and so on, until each pair of spaces contains two coils, one superposed on the other, every coil being formed of two layers of wire, with eight strands in each layer.

It is advisable, before winding the outer series of coils, to bind the inner series close to the core by a winding of stout linen thread at three equidistant points in the length of the armature. As a guard against the possibility of short circuiting, the terminals of each coil, where they are in contact with each other or with other portions of the wire, should be provided with an extra wrapping of cotton.

To avoid the destructive effects of centrifugal force, the armature, after winding, is encircled at three equidistant points in its length by three bands, each consisting of 8 or 10 convolutions of unannealed No. 30 brass wire, drawn tightly, and soldered at numerous points. A band of adhesive tape is interposed between the brass wire and the conductor of the armature. The armature thus constructed is known as the Siemens or Hefner-Alteneck armature.

There is another method of constructing the core of the armature which yields good results, but is, in some respects, inferior to the one described. The armature shaft carries a spool of well seasoned wood or other non-magnetic material, upon which is wound varnished soft iron wire—the wire being used instead of the iron rings.

The making of a good commutator is not the smallest item in the construction of a dynamo. It is a very important part of the machine, requiring good workmanship and the best of materials.

The commutator cylinder in a machine of this class is formed of a series of bronze bars, separated a short distance from each other, and carefully insulated. On the eight light dynamo it is 1¼ inches in diameter and 2 inches long. The bronze sleeve, A, which is fitted to the shaft and provided with a fixed flange and a set screw at one end, is screw threaded at the opposite end to receive the screw threaded bronze flange, B. On the sleeve, A, between the fixed flange and the removable flange, B, is placed a vulcanite sleeve, C, and to the ends of this sleeve are fitted two collars, D, of vulcanized fiber or analogous insulating material. These collars are beveled on their inner surfaces, and are thickest at their peripheries. To the vulcanite sleeve, C, is fitted a bronze cylinder, E, having conical ends, fitted to the beveled collars, D, as shown at 5 in Fig. 6. The bronze cylinder is slitted longitudinally in a gear cutter, or in any other convenient way, so as to divide it into 24 equal divisions, the slits extending nearly through the cylinder, as shown at 1. Before the bars are separated they are marked with figure punches, in regular order from 1 to 24, so that they may be rearranged after separation. Besides this, a sheet of mica is selected which can be crowded into the slits. Now, if the slits have been made deep enough, the bars may be broken off one after another, and the fin may be removed with a file; but if the bars cannot be broken off in this way, they may be removed by means of a hack saw, as shown at 2.

As many strips, F, of mica are cut from the sheet as

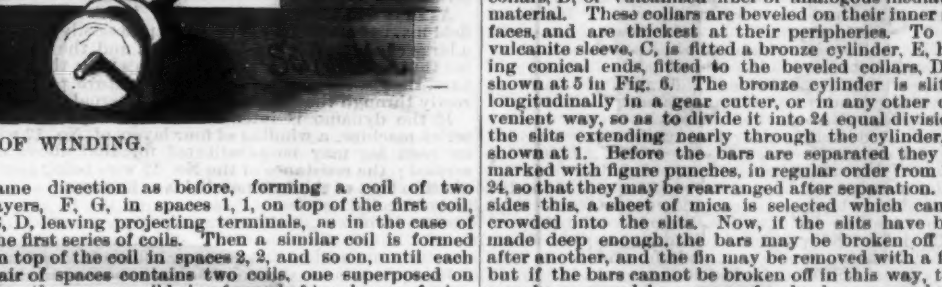


FIG. 4.—THE FIRST COIL ON ARMATURE.

* The wire used is the best cotton covered magnet wire.

there are bars in the cylinder, the mica strips being made a little wider than the bars and of exactly the same length, as shown at 3.

The commutator bars thus formed are placed between the collars, D D, in alternation with the mica strips, with the bars arranged according to their numbers. The flange, B, is then screwed up tightly, clamping all the bars and the mica strips firmly in their places, each bar being thoroughly insulated. The cylinder thus made is placed upon an arbor and carefully turned off to bring it to a true cylindrical form. After turning, each bar is drilled near one end to receive the brass screw by which the armature wire is connected with the commutator bar.

The commutator cylinder, now finished, is secured by the set screw in its place on the armature shaft, with the screws adjoining the body of the armature.

chine base, while the other communicates with one of the rods extending to the top of the field magnet. The remaining binding post on the base is connected with the other vertical rod, extending to the top of the magnet. These vertical rods are connected with the terminals of the winding of the field magnet, as shown in Fig. 1.

The circuit of the machine is clearly shown in Fig. 8, the current passing from the armature, C, through the upper brush, thence to the top of arm, A, of the magnet, down that arm, then up to the top, then down the arm, B, and up, then downward to the base of the machine, terminating at *a*. The lower or remaining brush is connected with conductor, *b*. From the terminals, *a b*, the current is taken off for use.

The portions of the field magnet to be covered with wire are carefully covered over with one thickness of

chine, and no further manipulation other than the adjustment of the brushes is necessary. The brushes should be adjusted to a point where the least sparking is produced. This will not vary much from the original position. The machine from which the engravings were made produces no noticeable sparks at the commutator.

If the machine fails to start, when tried in the manner above indicated, a battery of four or five Bunsen cells must be connected with the binding posts, or a dynamo may be used instead of the battery. It some-

FIG. 6.—THE COMMUTATOR CYLINDER.

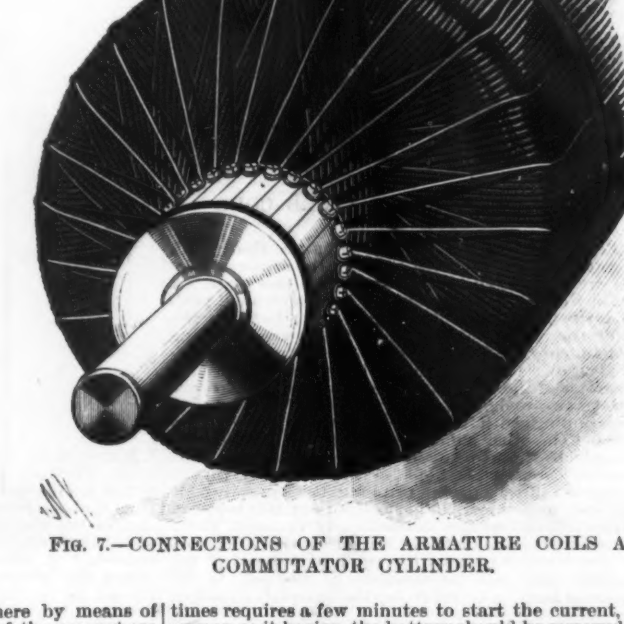


FIG. 7.—CONNECTIONS OF THE ARMATURE COILS AND COMMUTATOR CYLINDER.

Now, for convenience in handling, the armature shaft is placed in the lathe, and the inside and outside terminals of one coil are carefully straightened out parallel with the sides of the armature, and their ends are stripped of the insulating covering for a short distance and thoroughly scraped. The screws in two of the commutator bars, say 1 and 2, are loosened so as to permit of placing the looped ends of two wires under them. The outer terminal of the coil is connected with one of the screws, and the inner terminal of the same coil is connected with the screw in the next bar in order in the commutator cylinder. The outer terminal of the second coil is connected with the screw last referred to, and the inner end is connected with the screw of the next bar in advance, and so on around the entire commutator cylinder, the outer end of each coil being connected with inner end of the adjacent coil and with a bar of the commutator cylinder by one of the screws, as shown in Fig. 7.

The brushes which bear upon opposite sides of the commutator cylinder are each made of six thin strips of hard rolled copper, thirteen-sixteenths inch wide and

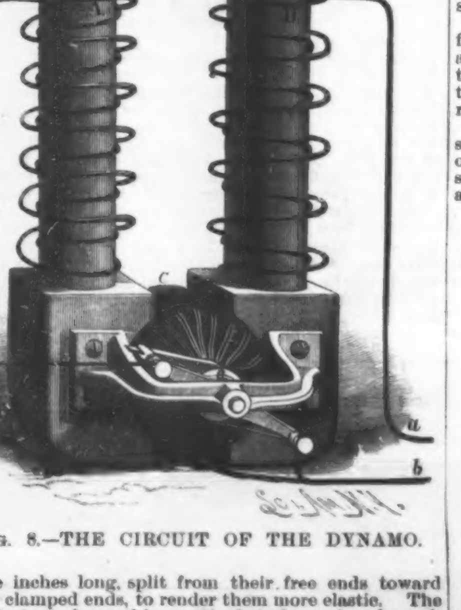


FIG. 8.—THE CIRCUIT OF THE DYNAMO.

three inches long, split from their free ends toward their clamped ends, to render them more elastic. The brushes are clamped in mortised studs passing through holes in the ends of a bar fitted to and adjustable on a boss formed on the inner side of the bronze yoke around the shaft. By this arrangement the brushes may be adjusted for taking off the current to the best advantage. The mortised studs which hold the brushes are separated electrically from the bar by insulating thimbles and washers, and upon the outer ends of the studs are screwed binding posts, in which are inserted conductors, bent into spirals to permit of the adjustment of the brushes. One of these conductors communicates with one of the binding posts on the ma-

cotton cloth, which is made to adhere by means of shellac varnish, and the shoulders of the magnet are lined with leather board, or thin sheets of vulcanite, or vulcanized fiber. The object of thus covering the field magnet is to insure good insulation.

In Fig. 8, for the sake of clearness, only a single conductor is shown on the field magnet, but in practice there are four, each conductor passing down and up once on each arm of the magnet; that is to say, there are eight layers of wire on each arm of the magnet, formed of four wires, each wire being laid on by beginning at the yoke, winding down to the shoulder of the polar extremity, then up again to the top, leaving the inside and outside ends projecting, as shown in Fig. 9. The winding is best done in a lathe.

In the present case all of the inner ends of the wires of the arms of the magnet are connected together, and all of the outer ends of one arm of the magnet are connected with one of the vertical rods, while the outer ends of the wires of the other arm are connected with the other vertical rod, as shown in Fig. 1.

By winding the field magnet with No. 18 wire in the manner described, several advantages are secured, one of which is the facility with which the work of winding may be done; another is the possibility of connecting the wires in different ways, so as to secure more or less resistance in the magnet. Another is that the wires may be conveniently connected up according to the various methods of winding, compound, shunt, series, etc.

As shown in the engravings, all of the wires of the field magnet are in parallel circuit, practically forming a large conductor of small resistance, and the conductor thus arranged is connected in series with the armature, that is, the current from the armature passes directly through the field magnet and external circuit.

If the dynamo is intended to be always used as a series machine, a winding of four layers of No. 12 wire on each leg may be substituted for that above described; the resistance of the No. 12 wire being equivalent to that of the four parallel No. 18 wires.

times requires a few minutes to start the current, but as soon as it begins, the battery should be removed.

Some care is necessary in handling the conductors, as it is quite possible to receive a severe shock from this machine.

Upon the annexed outline engravings—which are half size linear—are marked the dimensions of the several parts of the eight light dynamo; and as all of the dimensions may be taken from the figures there given, or from actual measurements of the drawing doubled, it will be unnecessary to go into further particulars regarding sizes.

The armature core shown in Fig. 14 requires a brief description. This core may be substituted for the one before described. To the armature shaft are secured two brass disks provided with shoulders on their inner faces which support a thin hollow cylinder or tube of iron or brass. This cylinder and the inner faces of the brass heads are covered with adhesive tape, and upon the spool thus formed No. 20 soft iron wire—previously varnished and dried—is wound in uniform layers until the core is of the proper diameter. The end of the iron wire is secured by scraping it and soldering it to the adjacent coil. The brass heads are slit radially to receive the vulcanite wedges as in the other case, and the entire core is well covered with adhesive tape, when the winding may be proceeded with.

As before mentioned, the winding of the field magnet with four parallel wires permits of arranging the magnet in various ways to secure a good automatic regulation of the current. The circuit of the machine as

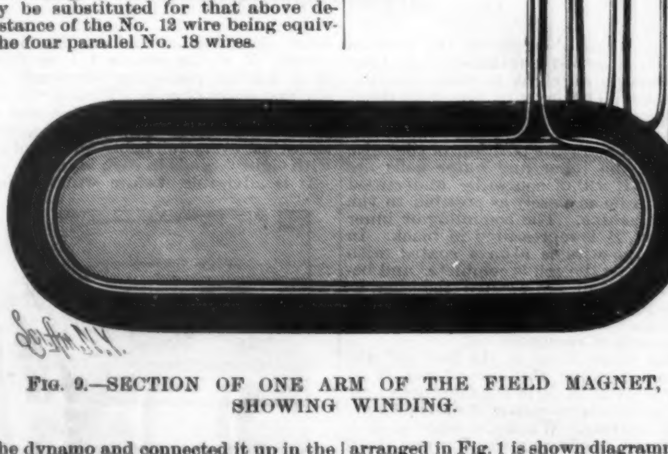


FIG. 9.—SECTION OF ONE ARM OF THE FIELD MAGNET, SHOWING WINDING.

Having made the dynamo and connected it up in the manner described, the brushes are to be brought into contact with the commutator cylinder at points diametrically opposite each other, and at points about opposite the center of the space between the polar extremities of the field magnet. The armature is revolved in the direction of the free ends of the brushes, and in the binding posts on the base are inserted short wires, which may be brought into contact with each other momentarily as the armature revolves.

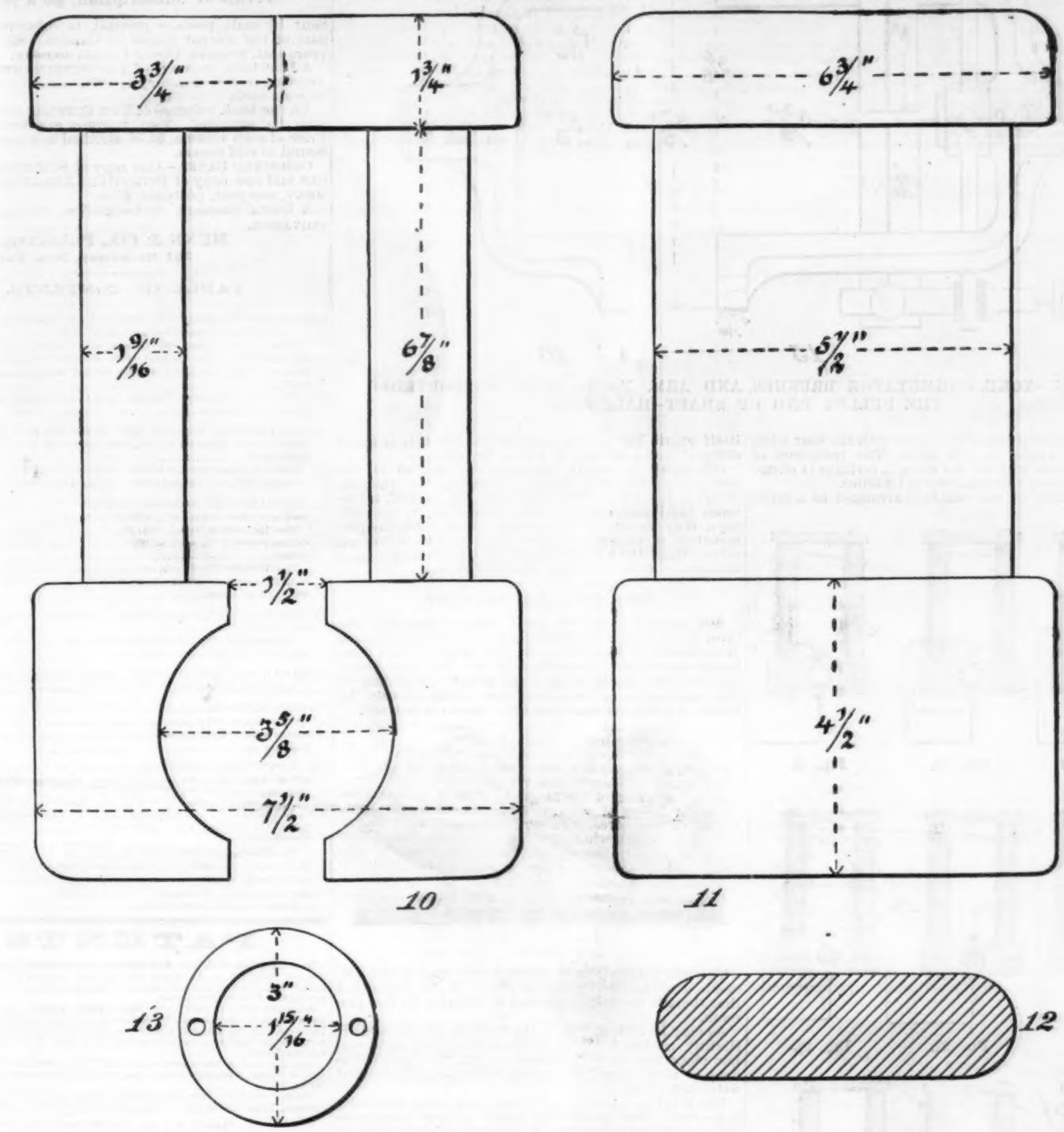
If a spark is seen on the separation of the wires, it shows that the magnetism inherent in the iron of the field magnet is sufficient for the starting of the ma-

arranged in Fig. 1 is shown diagrammatically in Fig. 17, to permit of comparing it with the diagrams that follow.

Fig. 2 shows the machine arranged as a shunt dynamo,* in which the terminals of the field magnet are connected with both commutator brushes, so that part of the current passes around the magnet and part through the external circuit. In this arrangement, however, the four wires of the field magnet are arranged in series, that is, terminal, 1, of the leg, A (see Fig. 1), is connected with one of the commutator

* Introduced by Wheatstone.

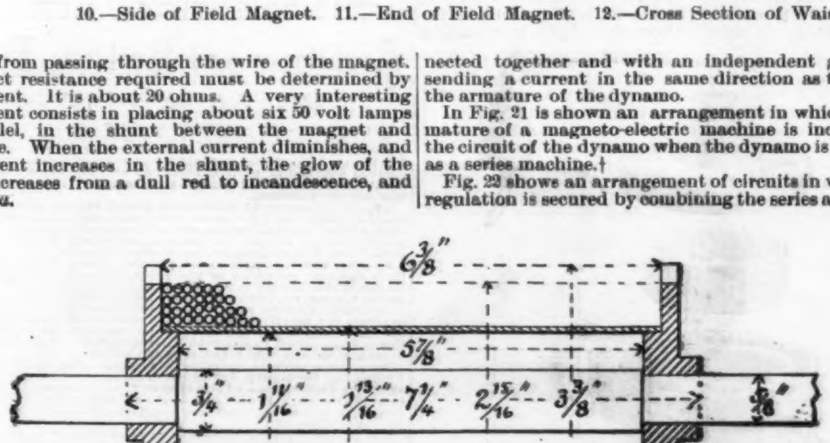
brushes; 2 is connected with 5, 3 with 6, and 4 with 7; 8 is connected with 8 of the leg, B, and 1 is connected with the remaining commutator brush; 2 is connected with 5, 3 with 6, and 4 with 7. Resistance must be placed between one of the terminals of the magnet and the commutator brush, to prevent too much of the



PARTS OF THE EIGHT LIGHT DYNAMO—HALF SIZE LINEAR. (Figures represent full size in inches.)

10.—Side of Field Magnet. 11.—End of Field Magnet. 12.—Cross Section of Waist of Magnet. 13.—One Ring of the Armature.

current from passing through the wire of the magnet. The exact resistance required must be determined by experiment. It is about 20 ohms. A very interesting experiment consists in placing about six 50 volt lamps in parallel, in the shunt between the magnet and armature. When the external current diminishes, and the current increases in the shunt, the glow of the lamps increases from a dull red to incandescence, and *vice versa*.



WIRE ARMATURE CORE—HALF SIZE. (Figures represent full size in inches.)

This is probably the best way to arrange the machine for use by hand power.

In Fig. 19 is shown the machine in which the field magnet is arranged to be excited by a separate generator,* such as a battery or another dynamo.

* Due to Wilde.

In Fig. 20 is represented an arrangement of circuits* in which are combined the features of Figs. 17 and 19. In this case three of the wires of each leg of the magnet are connected together in series, and also connected in series with the armature and with some resistance; the remaining wires of the legs of the magnet are connected together and with an independent generator sending a current in the same direction as that from the armature of the dynamo.

In Fig. 21 is shown an arrangement in which the armature of a magneto-electric machine is included in the circuit of the dynamo when the dynamo is arranged as a series machine.†

Fig. 22 shows an arrangement of circuits in which the regulation is secured by combining the series and shunt systems.‡ To adapt this system to the eight-light dynamo, the three of the magnet wires in series, including some resistances, should be connected as a shunt, and

* Due to Depretz.

† This arrangement was devised by Perry.

‡ Invented by Brush.

the remaining wires should be connected with the armature and external circuit in series, as indicated by the heavy line.

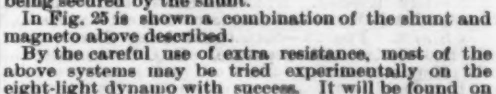
The arrangement shown in Fig. 23* is similar to that last described, but in this case the shunt is much longer, and is arranged across the external circuit. This system cannot be applied to the eight-light dynamo without applying a considerable length of fine wire to the coils of the field magnet. This is probably not advisable in the case of this machine.

In Fig. 24 is shown a system† of circuits in which the field magnet of the shunt machine shown in Fig. 18 is furnished with a conductor (shown in dotted lines), through which a current from an external source passes to constantly maintain the minimum of magnetization, the variation necessary to insure regulation being secured by the shunt.

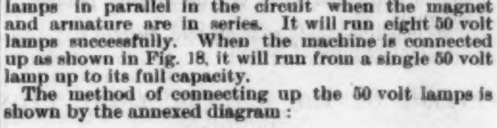
In Fig. 25 is shown a combination of the shunt and magneto above described.

By the careful use of extra resistance, most of the above systems may be tried experimentally on the eight-light dynamo with success. It will be found on trial that the current will not start with less than three lamps in parallel in the circuit when the magnet and armature are in series. It will run eight 50 volt lamps successfully. When the machine is connected up as shown in Fig. 18, it will run from a single 50 volt lamp up to its full capacity.

The method of connecting up the 50 volt lamps is shown by the annexed diagram:



Twenty-five volt lamps may be connected up two in series and eight in parallel as follows:



* S. P. Thompson.

† Depretz.

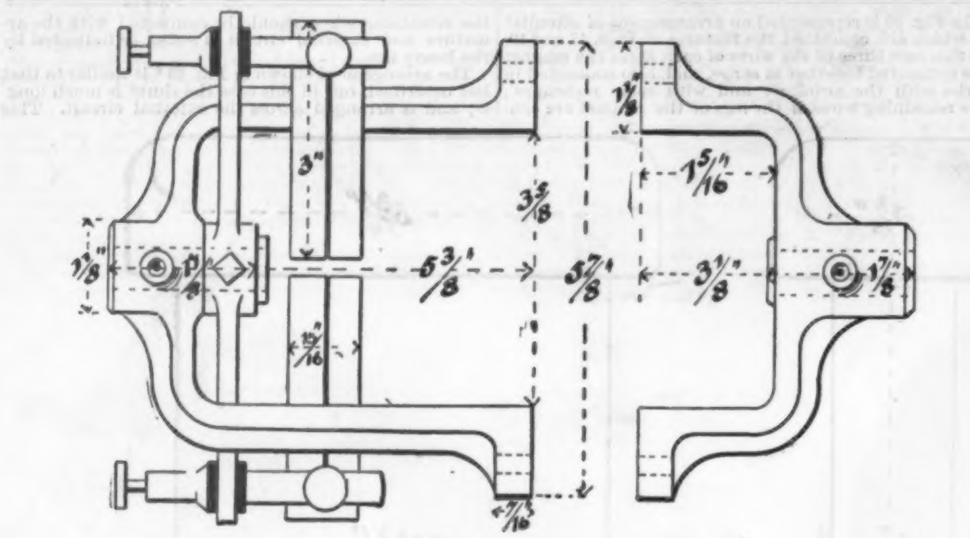


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FIG. 15.—YOKE, COMMUTATOR BRUSHES, AND ARM. FIG. 16.—YOKE SUPPORTING THE PULLEY END OF SHAFT—HALF SIZE.

The resistance of the field magnet with the four wires of each leg parallel is 0·086 ohm. The resistance of the field magnet with all the wires in series is 14 ohms. The resistance of the armature is 1·8 ohms.

The resistance of the machine arranged as a series

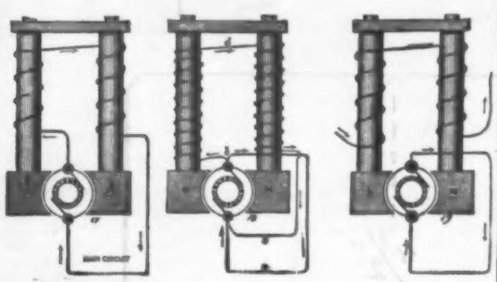

FIG. 17. FIG. 18. FIG. 19.

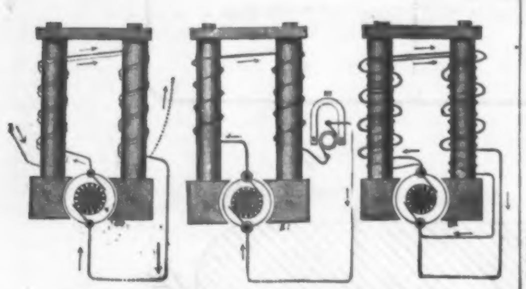

FIG. 20. FIG. 21. FIG. 22.

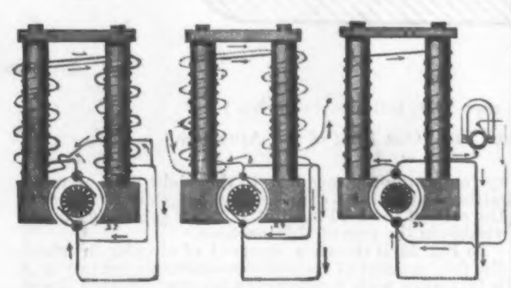

FIG. 23. FIG. 24. FIG. 25.

FIG. 17.—Series. FIG. 18.—Shunt. FIG. 19.—Separately Excited. FIG. 20.—Series and Separate. FIG. 21.—Series and Magneto. FIG. 22.—Series and Shunt. FIG. 23.—Series and Long Shunt. FIG. 24.—Series and Separate. FIG. 25.—Shunt and Magneto.

dynamo, with the wires of the magnet parallel, is 1·886 ohms.

This machine yields a 10 ampere current having an electromotive force of 60 volts.

EFFECT OF THE ELECTRIC LIGHT UPON BOOKS.

PROF. WIESNER, of Vienna, has just called attention to an inconvenience attending the use of the electric light in libraries. It has been found that a large number of works in the library of the Technical School had become very yellow, and this led the director of the establishment to ask Prof. Wiesner to ascertain the cause of it. Experiment has shown that the coloration is due to light, but that it occurs only with paper containing ligneous substances, such as wood, straw, and jute, and that it does not take place when, through some chemical process, the lignine that forms the essential part of the wood is removed. The yellowing is due to a phenomenon of oxidation. Solar light acts more energetically than dispersed daylight, which itself exerts but a very slight action when it is much diffused, and especially in a very dry room.

Gas light is nearly harmless, by reason of the few refrangible rays that it contains. On the contrary, as the arc electric light, and, in general, all intense luminous sources, emit numerous refrangible rays, they favor the yellowing. As regards the preservation of papers, then, it will be well to choose gas rather than the electric light for the illumination of libraries.—*Revue Internat. de l'Electricite.*

THE UPWARD BATTERY.

WE present herewith some data concerning the form of the Upward battery that is now in operation at Woodhouse & Rawson's. In this model there is no longer any need of expelling the air that may enter, and but two elements are employed, the charging of the accumulators being effected continuously by means of a commutator connected with the battery.

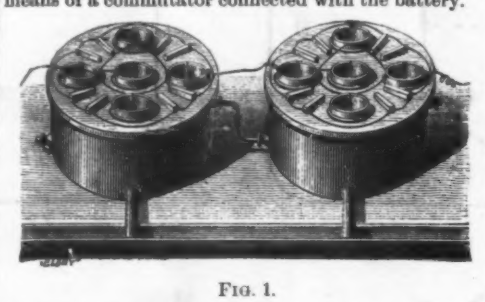

FIG. 1.

The gas always enters through the base of the elements, and thus drives the air before it. It is asserted that there is no disengagement of chlorine in the pile room.

As may be seen in Fig. 1, the form of the elements is slightly modified. Each of them comprises eight carbon plates connected for quantity, and five cleft cylinders of zinc placed in porous vessels and connected with each other.

But it is the retort (Fig. 2) that has been especially improved. The perforated vessel of terra cotta contains a sufficient quantity of binoxide of manganese to last for about three weeks. The daily charge of acid is easily introduced into the receptacle, which is independent of its cover. The acid is therefore never manipulated. It enters through a closed tube ending

FIG 2.

in a graduated reservoir, and the spent liquid flows into a drain. When it is necessary to renew the binoxide, the retort is washed with water, which enters through the same aperture that the acid does.

The entire surveillance of this plant is reduced to the daily maneuver of two cocks, and to a renewal, from time to time, of the charge of binoxide, an operation which, as we have seen from the description of the retort, is very easily performed. It seems certain, then, that this battery may be confided to the care of ordinary workmen.—*La Lumiere Electrique.*

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TABLE OF CONTENTS.

PAGE

I. ELECTRICITY.—Effect of the Electric Light upon Books.—Injury to bindings due to the actinism of the arc light.......... 9590

Eight Light Dynamo.—By GEORGE M. HOPKINS.—A full and detailed account of this machine, with elaborate instructions, enabling any one to construct it without further instructions.—25 illustrations.......... 9588

The Upward Battery.—The most recent modification of this battery.—2 illustrations.......... 9590

II. ENGINEERING.—Nossian's River Motor.—By JULIUS MAIER, Ph.D.—A new motor for utilizing waste power of large streams.—1 illustration.......... 9578

Rule for Measuring the Gauge of Railroads.—An Austrian instrument giving width and level of track.—1 illustration.......... 9587

III. METALLURGY.—Nickel and its Alloys.—Manufacture and properties of these compounds, with tables of analyses.......... 9584

The Hardness of Metals.—By Mr. THOMAS TURNER.—An interesting review of the work of different investigators of this difficult subject.......... 9584

The Herbertz Cupola.—A cupola with adjustable hearth and annular air opening; extraordinary economy of fuel attained by its use.—3 illustrations.......... 9583

IV. MISCELLANEOUS.—Composition of Mercury.—Note by A. C. COURSENS.......... 9585

Exhibition of Flax Cleaning Machinery in Chili.—Note of a prize exhibition, of interest to inventors.......... 9577

V. NAVAL ENGINEERING.—New German Torpedo Boats.—The torpedo cruisers recently built by Herr Schichau.—1 illustration.......... 9579

VI. ORDNANCE.—Elswick Exhibits of War Materials at the Newcastle Exhibition.—The guns and appliances from the famous Armstrong works.—Exhaustive account of large and small guns.—9 illustrations.......... 9573

VII. SANITARY ENGINEERING.—Filter Press for Sewage Sludge.—The Drake-Muirhead apparatus, with its manipulation.—3 illustrations.......... 9586

VIII. TECHNOLOGY.—Manufacture of Wire Ropes.—Full description of the process, from drawing the wire to twisting the ropes.—4 illustrations.......... 9580

The Manufacture of Gas from Paraffine Oil.—By Prof. W. IVISON MACADAM.—Account of an interesting and laborious investigation, with tabular statement of results.—Difficulty of producing a true gas.......... 9579

Power Required for Flour Mills.......... 9585